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beyond ferrites

SHOREHAM:
nuclear station in repose

EIA and AEA:
allies compared

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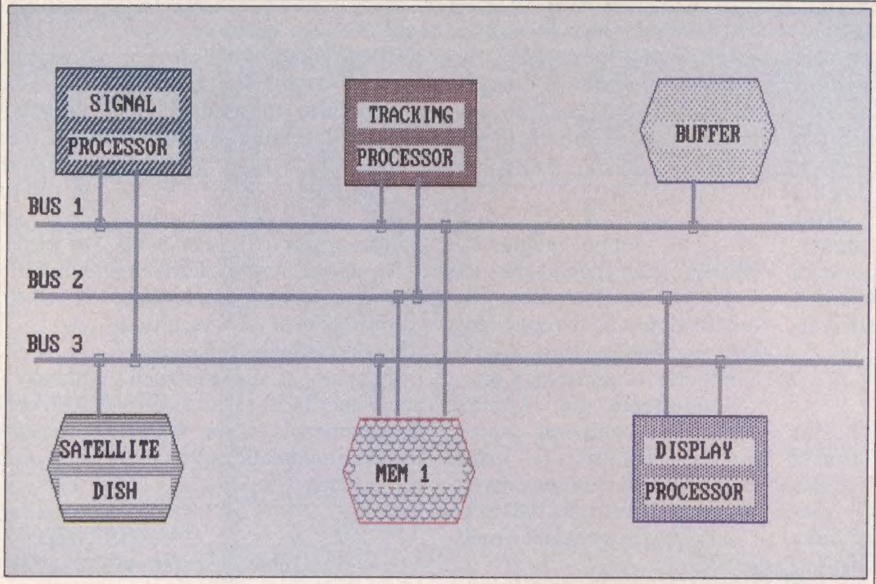

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NEWSLOG

MAR 14: A $150 million communications satellite, Intelsat F-6, owned by the International Telecommunications Satellite Organization, failed to separate from the final stage of a Martin Marietta Titan 3 commercial rocket after launching from Cape Canaveral, Fla., and went into such a low, lopsided orbit that it could re-enter the earth's atmosphere.

MAR 14: The U.S. Sprint Communications Co., Kansas City, Mo., announced plans to provide high-quality international telephone links to the Soviet Union by setting up a Moscow-based company, Telenet USSR, with the Soviet Union's Central Telegraph and Latvian Academy of Sciences.

MAR 19: Texas Instruments Inc. of Dallas said it would form a joint venture with Kobe Steel Ltd., Tokyo, to build a $450 million plant in Japan that will begin making advanced logic chips for the Japanese market in 1992.

MAR 19: Perkin-Elmer Corp., Norwalk, Conn., is selling its electron-beam lithography technology division to a management team backed by six corporations, including IBM Corp., Du Pont Co., and Grumman Corp. The new Etec Corp., based in Hayward, Calif., will help keep vital photomask technology in the United States.

MAR 20: Eleven years behind schedule and, at $6.5 billion, 12 times its original estimated cost, the Seabrook, N.H., nuclear power plant's 1150-megawatt reactor began operating after becoming licensed one week earlier.

MAR 21: The Federal Communications Commission (FCC) said it favored a simulcast system for high-definition television (HDTV) that would send a conventional TV signal on one channel and an enhanced high-definition signal on another.

MAR 24: Judge Vaughn R. Walker of the Federal District Court in San Francisco dismissed almost all the copyright lawsuit filed against Apple Computer Inc. by Xerox Corp., which alleged that Apple's Macintosh computer screen display unlawfully uses copyrighted technology developed by Xerox for its 1981 Star computer. Xerox said it would appeal.

MAR 26: The nuclear industry's first strike occurred at two Florida reactors and one in Georgia among two-thirds of itinerant radiation technicians employed there. The International Brotherhood of Electrical Workers, which already represents the majority of permanent workers at nuclear reactors, is seeking recognition as the bargaining agent for itinerant workers as well.

MAR 27: The United States and Japan said they have agreed to cooperate in research on: making submarines harder to detect; designing target-seeking devices for missiles; and developing a highly efficient rocket engine for missile systems. The deal is Japan's first postwar agreement to contribute its advanced technologies, particularly in microelectronics, to weaponry projects.

MAR 29: The Governor of Colorado urged the Department of Energy not to reopen the Rocky Flats, Denver, Colo., nuclear weapons plant until it has resolved a safety problem that allowed 28 kilograms of plutonium—seven nuclear bombs' worth—to escape into air ducts over the facility's 38-year operation. Plant officials said that the plutonium was contained and therefore not harmful to workers. The plant is scheduled to resume processing plutonium in June.

MAR 29: AT&T Co. announced plans to close 60 of its 160 Network Services Division work centers and lay off 6000 employees. The cuts, resulting from the company's conversion from analog to digital switching, were sharply criticized by the company's largest union, the Communications Workers of America.

MAR 29: To ease the creation of a single European market, the Spanish and West German telephone companies, Telefónica de España and Deutsche Bundespost Telekom, signed an agreement to improve communications links and establish digital circuits between the two countries.

MAR 30: A Federal judge temporarily allowed Motorola Inc., Schaumburg, Ill., to continue to sell its 68030 microprocessor, basic to several U.S.-made computers, one day after he had ordered a halt to its sales because the chip infringed a patent held by Hitachi Ltd., Tokyo. At the same time, Judge Lucius D. Bunton of Federal District Court in Austin, Texas, who had previously ruled that Hitachi had infringed on three Motorola patents, also lifted a ban on Hitachi's selling its H8/532 microcontroller, used in fax machines and copiers.

MAR 30: The Japanese Government agreed to delay any breakup of Nippon Telegraph & Telephone Corp. for at least five years. Officials attributed the decision to the political atmosphere caused by this year's steep drop in stock prices. Under the breakup plan, Nippon would have been left with only local calling, which has been subsidized by long-distance revenues.

APR 1: To modernize its communications systems, the Soviet Union said it will launch three giant telecommunications satellites on its Energia rocket in 1993. The satellites would provide USSR TV and radio communications as well as telephone service for regions without any.

APR 2: The European Community submitted a proposal for new international rules to protect rights to such intellectual property as patents for 20 years, copyrights for 25 to 50 years, and trademarks for 10 years.

APR 2: Dresden-based VEB Kombinat Robotron, East Germany's largest computer hardware and software company, began to split up as two of its 21 operating subsidiaries, Sommerda, which makes printers and office equipment, and Robotron-Messelektronik, a manufacturer of electronic testing and measuring equipment, announced plans to leave Robotron, the state-owned entity, and work with companies outside of East Germany.

APR 3: U.S. and Japanese officials announced an accord to allow non-Japanese producers to compete for the satellite business of the Japanese Government and its public-sector entities. The deal follows a March pact that opened the Japanese market for U.S. supercomputer and telecommunications companies.

Preview:

MAY 9: The National Aeronautics and Space Administration Agency is scheduled to launch a space shuttle that will use Astro-1 and broadband X-ray telescopes for astronomical tests. Seven astronauts will participate in the nine-day mission.

Coordinator: Sally Cahur

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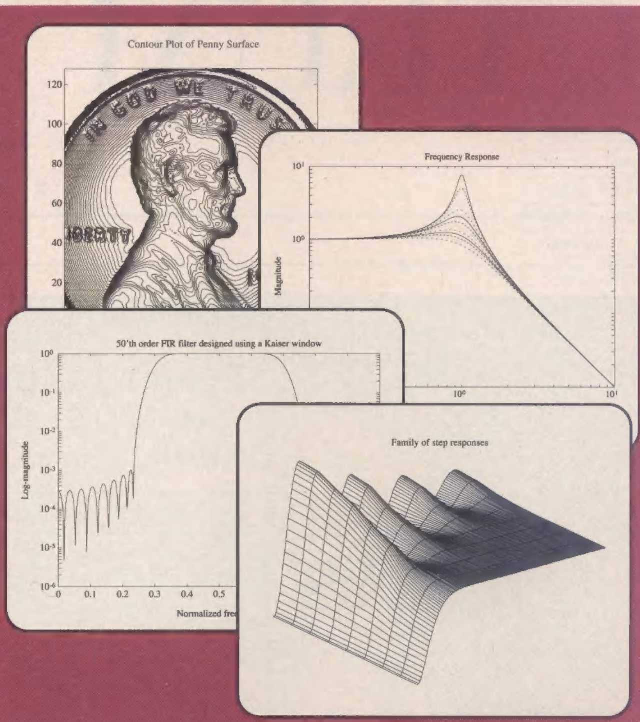

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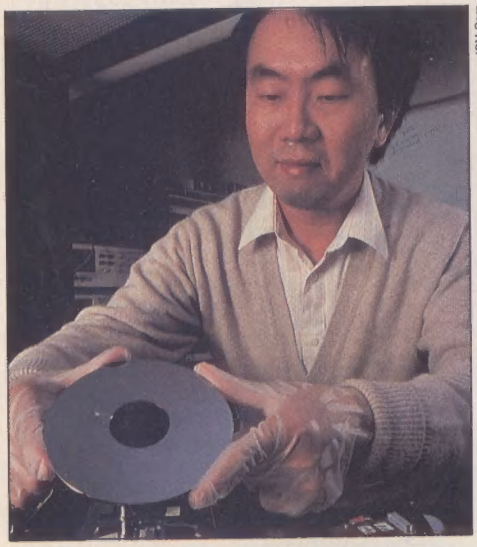

32 Researcher puts high-capacity magnetic disk on a lab test stand

40 Optical-fiber cable is installed for a metropolitan-area network

Cover: New York City has more pay phones than any other city—and more problems with vandalism, too. At a Manhattan telephone office on West 36th Street, photographer Günter Knop found this mound of casualties from the ongoing street battle. For a report on today's pay telephones, see p. 28.

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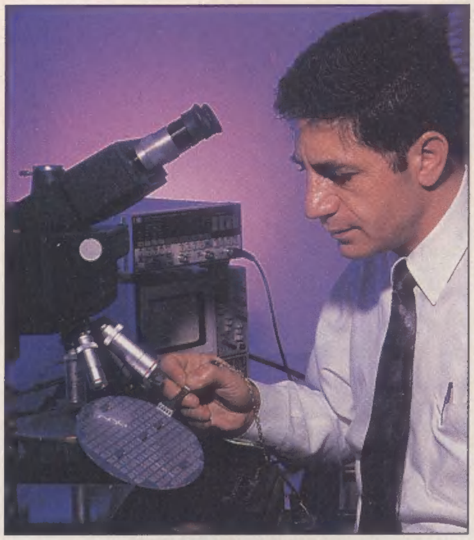

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Array of emergency phones sit in idle Shoreham power plant control room **46**

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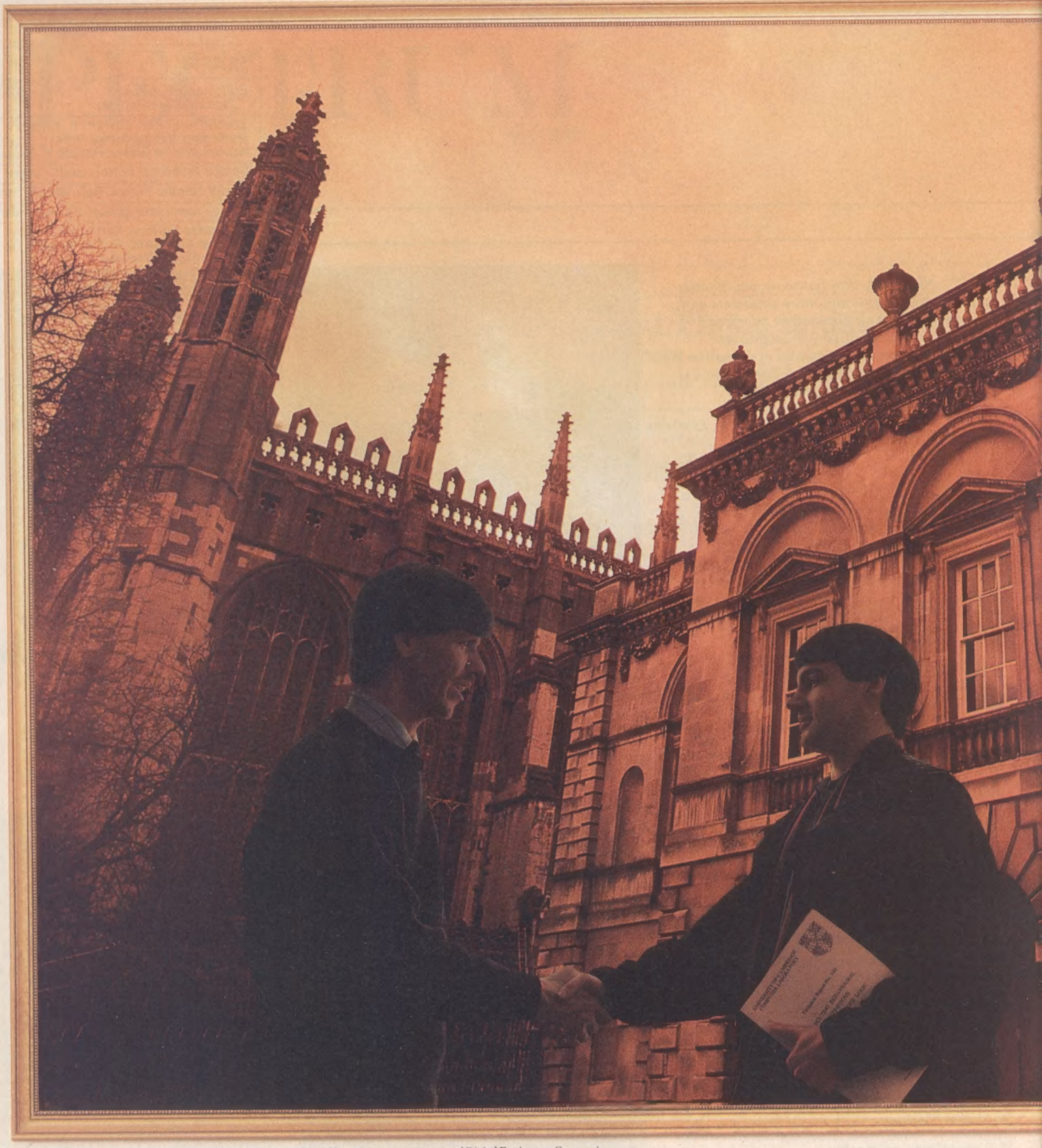

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Feedback

I was about to realize a fantasy. On the scale of fantasies, this was not one of major proportions, but life offers few enough such opportunities. Glancing once again at the stranger sitting next to me during the long plane flight, I monitored the progress of his page-by-page study of *Business Week* magazine. Lying on his briefcase at his feet were two other magazines presumably awaiting the same thorough scrutiny. The one on top was *IEEE Spectrum*—an issue containing one of my own columns.

I have never actually seen any real person reading something that I have written, and so I nervously anticipated his reaction. What better feedback than to gauge the rapport emanating from a total stranger cramped up against you as he reads words that not long ago had only been images in your brain! Even though in everyday conversation we see the effect our words have on the listener, the medium of writing is another matter entirely. The writer and the reader are separated by a chasm of distance, time, and anonymity. The loop is not meant to be closed.

As my seatmate reached for *Spectrum*, I took the opportunity to study him a little more closely. He would be a demanding critic, I thought. For one thing, he wore a vest, so I leaped to the conclusion that he was a formal sort of person. Moreover, he looked. . .well. . .tough. Nonetheless, I was ready for the challenge.

Finally, he reached the penultimate page, and I tuned my sensory perception to its maximum level. As the page was turned to my column, he folded the magazine back to get a better reading platform and settled into his seat. But before he had even gotten comfortable, he emitted a grunt of exasperation and turned the page decisively. After giving a kind of snort of derision and a little shake of his head, he resumed his in-depth reading of the material following my column. I had been ripped off—just like that!

Ah, well, such is life. Somebody once said that you cannot please all of the people all of the time. Intellectually, I know that, but it is a difficult principle to apply. Some years ago, I had to give a series of talks in a management forum. In order to help with the quality of presentation (so they said), the organizers collected feedback on each speaker. Shortly after each talk, I would be given the compilation of grades and comments on my presentation. I can assure you that was infinitely depressing. I discovered for the first time what I consider to be a fundamental law of public speaking: 10 percent of the people will hate you.

I remember one talk in the series especially well. My subject was "technology"—as opposed to "administration," "leadership," "business," and so on. As soon as I was introduced, a member of the audience raised his hand to ask a question. I had not yet even said a word. "Can you define 'technology'?" he asked. I stammered a bit. I mean, we all know what "technology" is, don't we? When I got the audience's feedback from that abortive talk, one of the forms rated me in the lowest possible category. "Speaker could not define 'technology'" was the added comment.

I got so gun-shy that I would look out at the audience before my talks and wonder who were those 10 percent out there who were going to dislike everything I said. Maybe they were the same people each time, being moved from talk to talk. As I was speaking, I would examine the audience for little indicators—such as falling asleep—that betray these secret antagonists.

In the years since this unfortunate revelation, I have had many subsequent occasions to verify the principle of the unimpressed. Now when they offer me feedback on a talk, I politely decline. I would rather imagine that the audience liked me than know the truth. Besides which, I have developed yet another theory about audience feedback: not only is it demotivating, but it is even unhelpful. One person will write that the talk was too theoretical, while another will say that it was too practical. One will say there was too much introduction, while another will say too little. The best you can hope for is to balance all of the negatives, but this hardly leaves you feeling very good about the whole thing. Balancing positives would leave a lot better taste.

I believe that most people have an intuitive sense about how well they themselves have done on a particular speech, writing, or job assignment. Deep down, we know the truth, so most of the time we prefer to hear lies or platitudes. In the case of a speech, I often feel that it is a real-time event that is a collaboration of speaker and audience, so I rationalize that the audience shares my ineptness. Sometimes I give a nearly identical speech to two different audiences. One audience seems to think it is great, while for the other, it falls completely flat.

Even when people praise your work, you are suspicious—sometimes with good reason. Not too long ago, I gave an after-dinner talk at a university. I did not do a good job. Afterwards, the departing streams of people formed two separate columns around me, creating a little lonely vacuum in the vortex that I alone inhabited. One elderly man approached me. "I really enjoyed your talk," he bubbled. I brightened. "If only the batteries in my hearing aid weren't so run down, I would have gotten more of it," he added. I dimmed.

Recently I participated in a meeting about something or other. It was probably terribly important at the time, but I have forgotten. What I remember was that afterwards a woman whom I had never met came up to me. "You're really a very funny man," she said. I wasn't sure what the correct response to this statement was, so I mumbled something incomprehensible and shook my head diagonally. She turned to leave, but as a sort of afterthought, added, "I don't know if you mean to be. . ." She left with the unfinished thought hanging in the air.

The other day I got feedback that for some perverse reason has bothered me unreasonably. About one of my talks, someone in the audience wrote, "OK—but not up to his usual standard." I thought, what kind of criterion is this? Do we always have to be better than we were on previous occasions? Are we never entitled to off days? Have mercy!

On the off chance that you are reading this on an airplane, smile at your neighbor. You never know. *—Robert W. Lucky*

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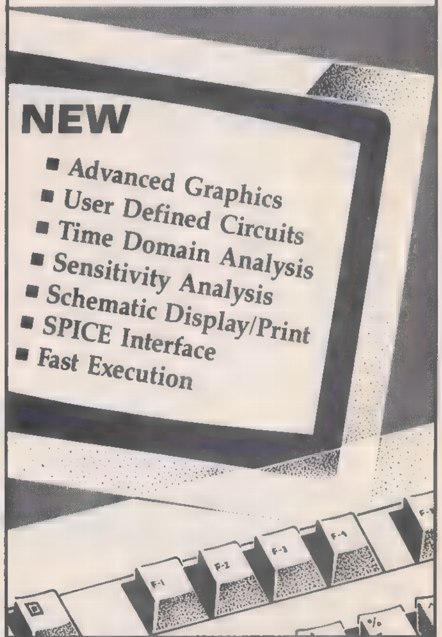

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I was about to realize a fantasy. On the scale of fantasies, this was not one of major proportions, but life offers few enough such opportunities. Glancing once again at the stranger sitting next to me during the long plane flight, I monitored the progress of his page-by-page study of *Business Week* magazine. Lying on his briefcase at his feet were two other magazines presumably awaiting the same thorough scrutiny. The one on top was *IEEE Spectrum*—an issue containing one of my own columns.

I have never actually seen any real person reading something that I have written, and so I nervously anticipated his reaction. What better feedback than to gauge the rapport emanating from a total stranger cramped up against you as he reads words that not long ago had only been images in your brain! Even though in everyday conversation we see the effect our words have on the listener, the medium of writing is another matter entirely. The writer and the reader are separated by a chasm of distance, time, and anonymity. The loop is not meant to be closed.

As my seatmate reached for *Spectrum*, I took the opportunity to study him a little more closely. He would be a demanding critic, I thought. For one thing, he wore a vest, so I leaped to the conclusion that he was a formal sort of person. Moreover, he looked . . . well . . . tough. Nonetheless, I was ready for the challenge.

Finally, he reached the penultimate page, and I tuned my sensory perception to its maximum level. As the page was turned to my column, he folded the magazine back to get a better reading platform and settled into his seat. But before he had even gotten comfortable, he emitted a grunt of exasperation and turned the page decisively. After giving a kind of snort of derision and a little shake of his head, he

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Turn on, tune up

Many times during my career as an amateur musician, playing the double-bass viol, I have been directed to tune my instrument to match a variety of other sources of the basic frequency, or pitch. This frequency is known in classical music circles as 440 A, meaning the frequency of "A above middle C," which is 440 hertz. Since the usual reference for this standard is an instrument such as an oboe, flute, or piano—all of which depend on the temperature of both the instrument and the player, or on other factors—this definition of the concert pitch is never very exact.

I have experimented with a completely different approach that does use a real standard. The double-bass (and the cello) has an open string that is tuned three octaves below the standard A pitch, at 55 Hz. If I pluck the open string while it is illuminated by fluorescent lights on a 60-Hz circuit, the string will demonstrate a beat frequency of vibration that is very noticeable to the eye.

If, however, I place a finger on the string at a point between B and B-flat, the beat frequency will decrease to zero, and the string will gently respond to the plucking by decreasing in amplitude smoothly to zero. Once the string has been tuned to the quarter tone between B and B-flat, tuning the rest of the strings is easy.

Howard Hamer
Long Branch, N.J.

Sky-earth capacitive coupling

Rocket measurements of transient electric fields above thunderstorms have led to the conclusion that the coupling of energy among regions of the atmosphere, ionosphere, and earth is much stronger than originally anticipated, and that this is due to phenomena akin to what electrical engineers call capacitive coupling, which had been generally neglected. These results may have application to a wide variety of phenomena.

A number of rockets have been launched above thunderstorms at the National Aeronautics and Space Administration's Wallops Island, Va., facility. Groups from Cornell University, Ithaca, N.Y., and Penn State University, University Park, Pa., have measured transient electric field waveforms associated with lightning return strokes at altitudes from 25 to several hundred kilometers. Rather than the generally expected "relaxation" decay transients, much wider pulses were observed, indicating much stronger electric energy coupling to the ionosphere than can be explained by electromagnetic radiation from the return stroke currents.

Subsequently, theories were developed to explain this, which have been verified by experiment. The realization that the currents to the ionosphere must return in the earth led to measurements by Penn State at an underground site, where transients containing orders of magnitude more energy than had been predicted by wave-coupling models were observed. The Cornell group has demonstrated that the long-duration transients penetrate the ionosphere to altitudes of at least hundreds of kilometers, where they may excite plasma instabilities.

Although the theory rests on solutions of the complete Maxwell's equations, a simplified view explaining the basic energy relationships involves the use of capacitors representing the thundercloud and cloud-to-earth energy storage, and both capacitive and conductive coupling to the ionosphere and "global circuit." Concepts that are invalid in media of spatially varying conductivity (and can lead to grossly erroneous solutions) include the use of images and the attribution of distinct meaning to the terms radiation, induction, and electrostatic. The common assumption of the conservative field condition, curl E = 0, mathematically forbids a capacitor to discharge into a parallel resistor and has led to errors of many orders of magnitude, even in the case of slow transient decay. More accurate analytical and computer models show that the transient decay waveforms of currents in the earth and ionosphere are controlled by the conductivity profile of the intervening "middle" atmosphere.

These results may have wider application. Capacitive coupling, using standard high-voltage transmission-line technology, may be an easier way to excite the transverse electromagnetic mode (TEM) of the earth-ionosphere transmission line at extra-low frequencies (ELF) than schemes for "radiation" of the energy. There is possible relevance to some of the bizarre electrical effects observed in nuclear weapons tests, such as Starfish in 1962. Relatively distant lightning can couple much larger currents than had been expected to grounded conductors, such as pipelines, rocket launch rails, and computers. Lightning-related magnetospheric transients may capacitively trigger other lightning, giving an explanation for multiple-stroke chain-reaction events.

In situations involving spatially varying electrical conductivity, from microelectronic devices to cosmic plasmas, it may be advisable that the complete Maxwell's equations be used to keep track of the space charge, or at least not to neglect capacitive energy storage and coupling.

Leslie C. Hale
University Park, Pa.

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues.

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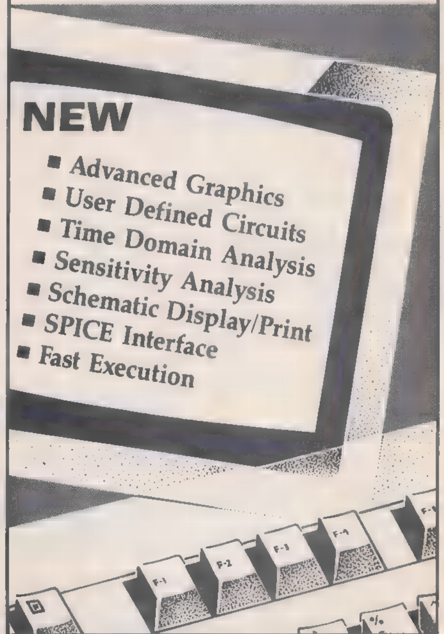

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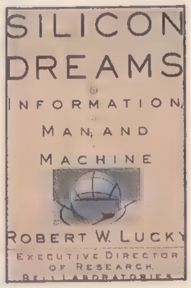
Silicon Dreams: Information, Man, and Machine. *Lucky, Robert W.*, St. Martin's Press, N.Y., 1989, 411 pp., $19.95.



"What I consider a fascinating paradox...is the fact that we have to devote about 100 million bits per second to create a typical network television picture on your TV screen. But then you sit there in front of that bitwise voracious display and ingest only your meager few dozen bits per second."

Readers of this magazine may recognize the tone of those sentences as coming from the insightful yet prosaic pen of Robert Lucky, executive director of research at AT&T Bell Laboratories and author of *IEEE Spectrum's* Reflections column. This book is replete with similar observations, which at first may seem merely witty, but which on second thought reveal a profound understanding of the nature of information and the relationship between man and machine.

At Bell Labs, Lucky has had contact with some of the great scientific and technical minds of this century, and he enjoys a little name-dropping. For this he can be forgiven, as his anecdotes are always entertaining, even if their connection to the rest of the book is tenuous. His retelling of Dave Hagelbarger's creation of a "mind-reading machine," which tried to predict a human opponent's heads-or-tails guesses in a series of coin flips, captures the obsessed enthusiasm the machine inspired throughout the mathematical research department at Bell Labs. The story culminates with a head-to-head competition with Claude Shannon's own clairvoyant contraption, which won by a narrow margin. The glimpse of a corporate research environment bubbling over with intellectual energy is fascinating.

Shannon, and his theory of information, are the heroes of this book. Lucky realizes he cannot convey the beauty of the concrete, engineered systems he discusses later in the book without giving the reader an appreciation of the mathematical concepts that let these systems be designed, built, and analyzed.

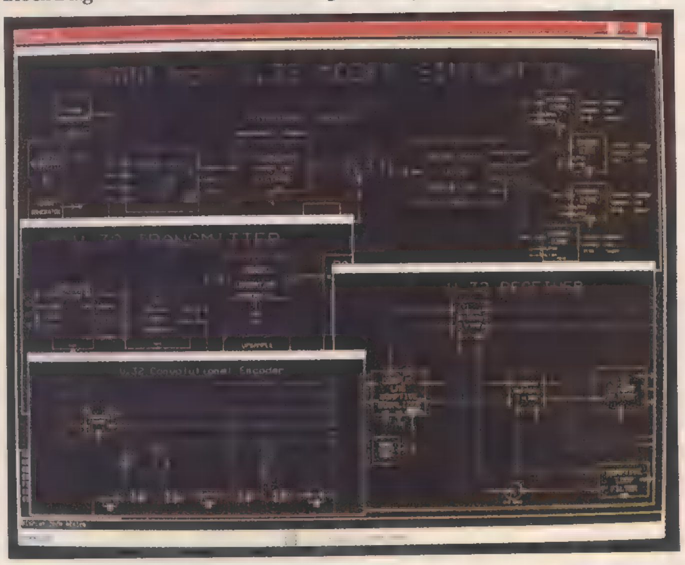
To construct a model of information that would have practical value, Shannon had to explicitly ignore the role of high-level semantics. Information is contained completely and austerely in the flow of bits through a system. The key insight was that there is a level of meaning in the *patterns* of the bits. Information is conveyed when the patterns change, and the quantity of information is proportional to some function of the *newness* of the patterns. Once this is grasped, it becomes clear why information systems can best be characterized by statistical properties.

What is remarkable is the degree to which analysis of the low-level statistics of a system automatically reveals the high-level semantic structure. For example, the 8-bit-per-character representation of English text employed universally in computer systems could be reduced to about 2.5 bits if the ways in which letters are grouped into words were considered.

Shannon's theory is the thread on which the sections of the book are linked. As Lucky proceeds through descriptions of various information-processing systems, he continually quantifies the information content of each system and compares it to human information-processing capabilities. He begins with simple coding schemes and proceeds through text and speech to image processing.

Lucky has taken obvious care to be accurate in a broad range of technical areas. As a researcher in the field of speech recognition, I found myself nodding and smiling while reading his material on that subject. He does not probe deeply into technical details, but does convey the essence of the problems I face every day. In

Block Diagram Editor windows showing hierarchy of V.32bis modem



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so doing, he proves that simplification need not equate with misinformation.

The idea of applying multiple sources of information to an acoustic signal, as a sort of shortcut through the search space of all the possible linguistic paths represented by that signal, is a central aspect of speech recognition. Yet it is seldom addressed in surveys of the topic. Thus it was a pleasant surprise to find most of the essentials in Lucky's book, which is intended for the ("determined") general reader. I suspect that experts in other technical areas will have the same reaction.

The problem of large search spaces arises almost exclusively in the context of recognizing *continuous* speech. That the author focuses considerable energy on this [redacted] is largely due to his overriding concern for the human half of the equation. He cites numerous experiments, not to mention personal experiences, which demonstrate that the halting, disconnected speech that can be recognized by some commercial systems is [redacted] nuisance, at best, for the speaker. The simplicity of isolated-speech recognition algorithms may be attractive to engineers, but Lucky argues forcefully that the information age requires us to design machines that conform to human expectations and abilities. We have the power to improve machines, but little ability to modify millions of years of biological evolution. This is the true meaning of "user friendliness."

Lucky surrounds tutorial sections on specific technologies with informal ruminations on such topics as what it's like to use these technologies, the personalities of the individuals who design them, and the human perceptual system's ways of dealing with information. With the perspective shifting so smoothly from that of an engineer to that of a user (and sometimes to that of [redacted] bemused alien observer), the reader is surprised to see technical language creeping back into the narrative. I found the author's discussions of art, music, and literature refreshing. He seems a living indication that a kind of renaissance awaits in the synthesis of the humanities with information science.

At times this style can be confusing. On occasion the author seems to be leading his readers down so many garden paths at once as to disorient them. Sometimes, he offers parenthetic comments in the midst of digressions; the effect is one of recursive digression! On the whole, however, most readers will probably find the entertainment value of these diversions and digressions worth a bit of confusion.

This is not to say that I agree with every musing or speculation he can dish out. Lucky freely admits that his personal observations may be controversial, as they are often supported by anecdote alone. Particularly shaky are discussions of the impact of mechanization on society. A healthy amount of skepticism and critical evaluation are warranted whenever the narrative addresses this subject. The author is neither political philosopher nor economist; nor does he claim to be.

Silicon Dreams should appeal to [redacted] wide audience. Those who understand information theory in [redacted] specific context will learn much from seeing it applied to [redacted] range of topics. Engineers will enjoy the descriptions of "real-world" systems. The book well conveys what it is like to be an engineer, the kind of problems one works on, and solutions available.

As an engineer, the author [redacted] keenly conscious of the fact that machines are made in the image of their creator. As a user of machines, he is also [redacted] of the contrast between the natural and the artificial. But he [redacted] no inherent barrier between the two worlds. Their ultimate merging will favor humans, but only when [redacted] understand much better how humans deal with information.

—*Roger S. Zimmerman*

Roger S. Zimmerman is a research engineer at Voice Processing Corp., [redacted] Cambridge, Mass., builder of systems for speaker-independent, continuous-speech recognition. An expert beer brewer, he holds an Sc.B. in acoustics from Brown University in Providence, R.I.

Coordinator: Glenn Zorpette

RECENT BOOKS

The Conquest of the Microchip. *Queisser, Hans,* Harvard University Press, Cambridge, Mass., 1990, 200 pp., $9.95.

How to Be [redacted] Successful Computer Consultant. *Simon, Alan R.,* McGraw-Hill, New York, 1990, 259 pp., $19.95.

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MEETINGS □ CONFERENCES AND CONVENTIONS

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For additional information on hotels, conference centers, and travel services, see the Reader Service Card.

MAY

Custom Integrated Circuits Conference-CICC '90 (ED); May 13-16; Westin Hotel Copley Place, Boston; Laura A. H. Morihara, Convention Coordinating, 298 Ohina Place, Kihei, Maui, Hawaii 96753; 808-879-9128.

Sixth Semi-Insulating III-V Materials Conference (Region 7, SIMC/IAC); May 13-16; Toronto Prince Hotel, Toronto; Carla J. Miner, Bell-Northern Research, Box 3511, Station, Ottawa, Ont. K1Y4H7, Canada; 613-763-3548.

International Conference on Applications of Industrial Electronic Systems (IA et al.); May 13-17; Hyatt Regency Hotel, Jerusalem, Israel; Moshe Harpaz, Kibbetz Ein-Carmel, D.N. Hof-Carmel 30 860, Israel; (972+4) 844 410.

International Conference on Robotics and Automation (RA); May 13-18; Hyatt Regency, Cincinnati, Ohio; Harry Hayman, Box 3216, Silver Spring, Md. 20901; 301-434-1990.

International Appliance Technical Conference (IA); May 15-17; Ohio State University, Columbus; Charles Sepsy, Mechanical Engineering Department, Ohio State University, 206 W. 18th St., Columbus, Ohio 43210; 614-292-6898.

Communication in the ISDN (German Section); May 16-18; Berlin; Secretariat, IEEE German Section, Stresemannallee 15, VDE-Haus, D-6000 Frankfurt 70, West Germany; (49+69) 630 8221.

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Workshop on Advanced Solid-State Imagers (ED); May 18-20; Columbia University, Arden House Conference Center, Harriman, N.Y.; Eric R. Fossum, Columbia University, Department of Electrical Engineering, 1312 S.W. Mudd St., New York, N.Y. 10027; 212-854-3107.

Electronic Components and Technology Conference (CHMT); May 20-23; Bally's Casino, Las Vegas, Nev.; James A. Bruorton, Kemet Electronics Corp., Box 5928, Greenville, S.C. 29606; 803-963-6621.

International Conference on Plasma Science (NPS); May 20-23; Hyatt Oakland, Oakland, Calif.; Noreen M. Curry, Physics International Co., 2700 Merced St., Box 5010, San Leandro, Calif. 94577-0599; 415-577-7237.

International Geoscience and Remote Sensing Society (GRS); May 20-24; University of Maryland, College Park, Md.; James A. Smith, NASA/GSFC, Code 623, Greenbelt, Md. 20771; 301-286-7282.

32nd Cement Industry Technical Conference (IA); May 21-24; Innisbrook Resort, Tarpon Springs, Fla.; E.A. Buehler, Polysius Corp., 180 Interstate North, Atlanta, Ga. 30339; 404-955-3660.

Conference on Laser and Electro-optics/International Quantum Electronics Conference-CLEO/IQEC '90 (IEEE/LEOS et al.); May 21-25; Anaheim Convention Center, Anaheim, Calif.; Glenda McBride, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 201-562-3896.

International Semiconductor Manufacturing Science Symposium (ED); May 21-25; Burlingame, Calif.; Pat Smith, SEMI, 805 E. Middlefield Rd., Mountain View, Calif. 94043; 415-940-6934.

National Aerospace and Electronics Conference (AES et al.); May 21-25; Dayton Convention Center, Ohio; Sue Brown, ASD/ENES, Wright-Patterson AFB, Dayton, Ohio; 512-255-6281.

21st IEEE Photovoltaic Specialists Conference (ED); May 21-25; Hyatt Orlando Hotel, Kissimmee, Fla.; John Meakin, University of Delaware, Institute of Energy Development, Newark, Del. 19716; 302-451-1672.

First Conference on Visualization in Biomedical Computing (COMP et al.); May 22-25; Ritz-Carlton Buckhead, Atlanta, Ga.; Norberto F. Ezguerra, Bioengineering Center, Georgia Tech, Atlanta, Ga. 30332; 404-894-7026.

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CALENDAR

(Continued from p. 14)

American Control Conference-ACC '90 (CS); May 23-25; Sheraton Harbor Island, San Diego, Calif.; Michael K. Masten, 2309 Northcrest, Plano, Texas 75075; 214-462-2460.

44th Annual Frequency Control Symposium (UFFC); May 23-25; Stouffer Harbor Place Hotel, Baltimore, Md.; Raymond L. Filler, U.S. Army ET&D Laboratory, Attn: SLCET-EQ, Fort Monmouth, N.J. 07703; 201-544-2467.

Second Intersociety Conference on Thermal Phenomena in the Fabrication and Operation of Electronic Components (CHMT); May 23-25; Bally's Casino, Las Vegas, Nev.; Paul Wesling, Tandem Computer Inc., 19333 Vallco Parkway, Cupertino, Calif. 95014; 408-725-6472.

20th International Symposium on Multiple Valued Logic (COMP); May 23-25; Hilton at University Place, Charlotte, N.C.; George Epstein, Department of Computer Science, University of North Carolina, 214 Kennedy Building, Charlotte, N.C. 28223; 704-547-4566.

17th International Symposium on Computer Architecture (COMP et al.); May 28-31; Stouffer Madison Hotel, Seattle, Wash.; J.L. Baer and L. Snyder, Department of Computer Science, University of Washington, FR-35, Seattle, Wash. 98195; 206-543-1695.

Electron, Ion, Photon Beam Symposium (ED); May 29-June 1; Hyatt Regency Hotel, San Antonio, Texas; Jon Orloff, AP/EE, Oregon Graduate Center, 19600 Von Neumann Dr., Beaverton, Ore. 97006; 503-690-1131.

International Conference on Distributed Computing Systems (COMP); May 29-June 1; Paris, France; ICDCS-10, IEEE Computer Society, Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036; 202-371-1013.

JUNE

Workshop on Numerical Modeling of Processes and Devices for Integrated Circuits: NUPAD III (ED); June 3-4; Hilton Hawaiian Village, Honolulu, Hawaii; Fely Barrera, AEL 205, Stanford University, Stanford, Calif. 94305; 415-723-1349.

International Symposium on Electrical Insulation (DEI); June 3-6; L'Hotel, Toronto; Greg C. Stone, Department of Electrical Engineering, Ontario Hydro, 800 Kipling Ave., KR151, Toronto, Ont. M8Z 5S4, Canada; 416-231-4111, ext. 6032.

Symposium on Computer-Based Medical Systems (COMP et al.); June 3-6; Carolina Inn, Chapel Hill, N.C.; H. Troy Nagle, North Carolina State University, Department of Electrical and Computer Engineering, Box 7911, Raleigh, N.C. 27695; 919-737-3578.

Infocom '90 (COM); June 3-7; Hotel Nikko, San Francisco; John Silvester, Department of EE Systems, SAL 340, University of Southern California, Los Angeles, Calif. 90089; 213-743-8189.

Fifth Annual Symposium on Logic in Computer Science-LICS '90 (COMP, TC); June 4-7; University of Pennsylvania, Philadelphia; Albert Meyer, Laboratory for Computer Science, 545 Technology Square, NE 43-315, Cambridge, Mass. 02139; 617-253-6024.

Solid State Sensor and Actuator Workshop (ED); June 4-7; Mariner's Inn, Hilton Head Island, S.C.; G. Benjamin Hocker, Honeywell Inc., 10701 Lyndale Ave. South, Bloomington, Minn. 55420; 612-887-4455.

Symposium on Autonomous Underwater Vehicle Technology (OE); June 5-6; Marriott Hotel, Dulles Airport, Washington, D.C.; Suzanne Kuntz, 655 15 St., N.W., Suite 300, Washington, D.C. 20005; 202-639-4524.

Workshop on Rapid System Prototyping (COMP, TC, ACM); June 5-7; Sheraton Hotel, Raleigh, N.C.; Kenneth Anderson, Siemens Corporate Research, 755 College Rd. East, Princeton, N.J. 08540; 609-734-6550.

Global Satellite Communications Symposium (COM); June 5-8; Nanjing, China; William W. Wu, Intelsat, 3400 International Dr., N.W., Washington, D.C. 20008; 202-944-7224.

International Conference on Consumer Electronics-ICCE (CE); June 6-8; Westin Hotel O'Hare, Rosemont, Ill.; Diane D. Williams, 131 Ledgewood Dr., Rochester, N.Y. 14615; 716-865-2938.

International Symposium on Application of Ferroelectrics (UFFC); June 6-8; University of Illinois, Urbana; G. Coad, Department of Material Science and Engineering, University of Illinois, 105 S. Goodwin Ave., Urbana, Ill. 61801; 217-333-2937.

Power Electronics Specialist Conference-PESC '90 (PEL); June 10-15; Hilton Palacio Del Rio, San Antonio, Texas; Mehrdad Ehsani, Department of Electrical Engineering, Texas A&M University, College Station, Texas 77843; 409-845-7441.

IFIP Workshop on Design and Test ASIC (COMP); June 11-12; Hiroshima Grand Hotel, Japan; Kozo Kinoshita, Hiroshima University, 1-180 Higashisendacho, Naka-ku, Hiroshima-shi 730, Japan; (81+87) 249 9150.

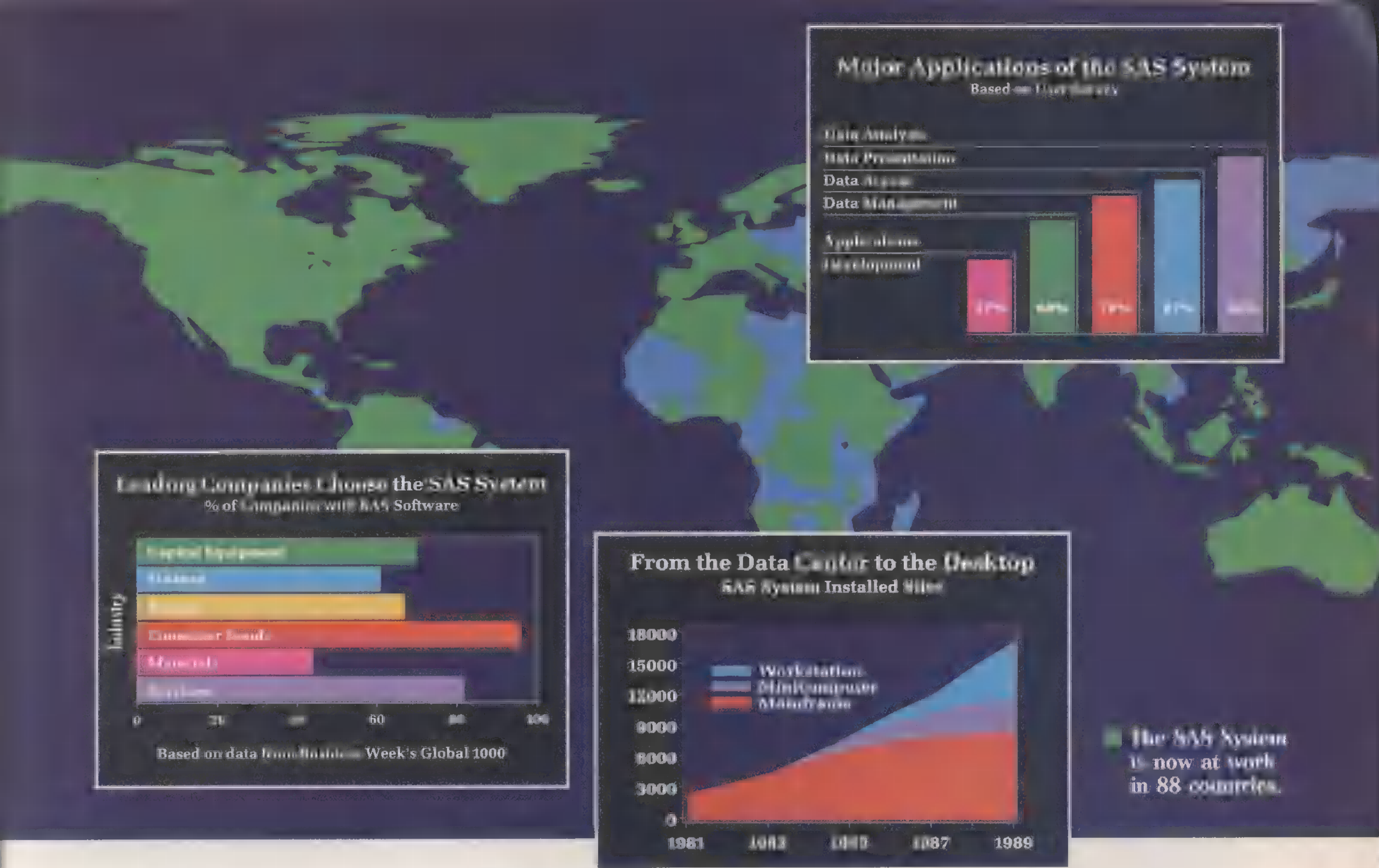
Conference on Precision Electromagnetic Measurements-CPEM '90 (IM); June 11-14; Westin Hotel, Ottawa; Huguette Lacoste, Conference Services, Building M19, Montreal Road, National Research Council, Ottawa, Ont. K1A 0R6, Canada; 613-993-9431.

Eighth International Congress of Cybernetics and Systems (IEEE); June 11-15; Hunter College of the City University of New York, New York City; Kathy Jaeger, Hunter College Department of Computer Science, 695 Park Ave., New York, N.Y. 10021; 212-772-5213.

International Joint Conference on Neural Networks-IJCNN (IEEE); June 17-21; San Diego Marriott Hotel & Marina, San Diego, Calif.; Nomi Feldman, Meeting Management, 5665 Oberlin Dr., Suite 110, San Diego, Calif. 92121; 619-453-6222.

10th International Conference on Pattern Recognition (COMP); June 17-21; Resorts International Hotel, Atlantic City, N.J.; Herbert Freeman, CAIP Center, Brett and Bowser

(Continued on p. 14N)



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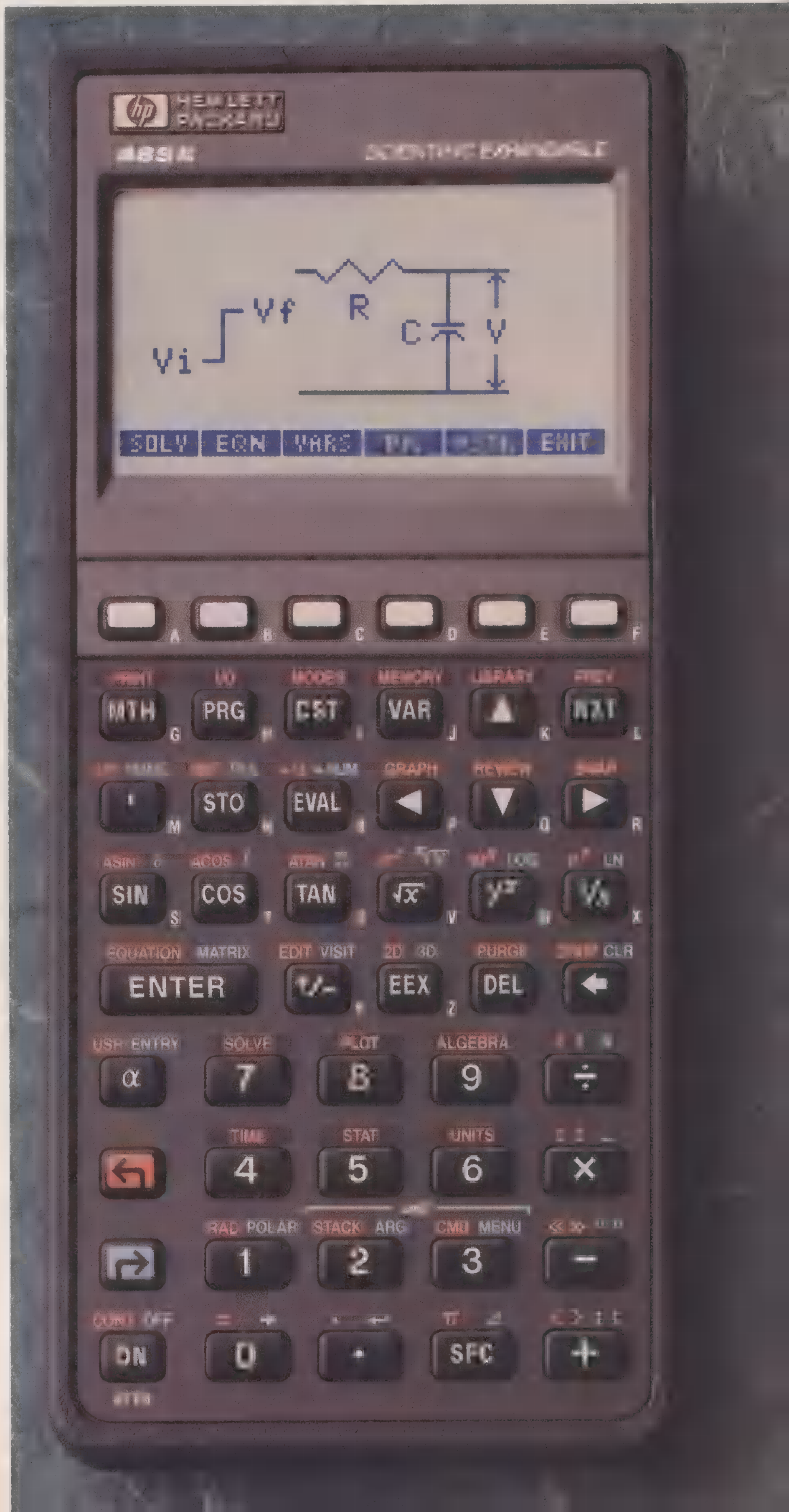
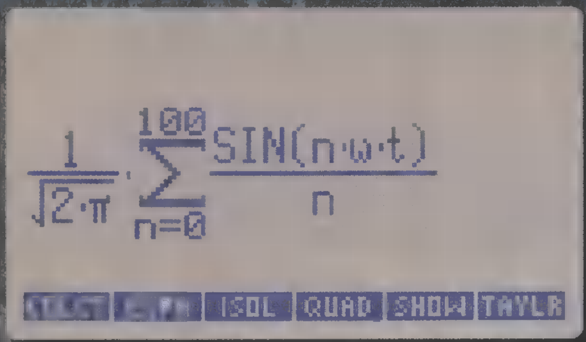


ator to come along in the next ten years.



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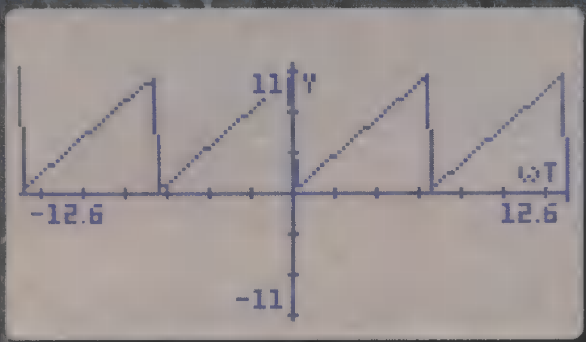

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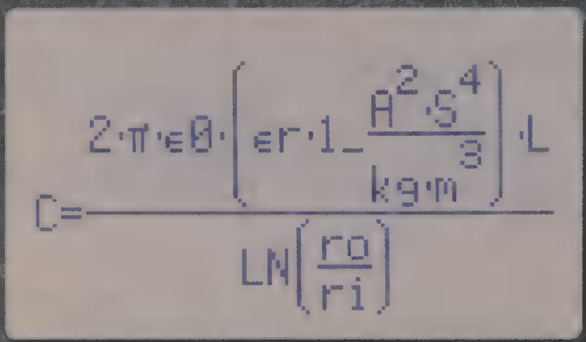

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- Page mode interleaved memory architecture.
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- Enhanced 101-key keyboard.
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   D ☐ UNIX-based systems
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   F ☐ Other
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   A ☐ Home B ☐ Business
3. How many PCs do you (your company) plan to purchase in the next twelve months?

Timeframe	Quantity
A ☐ Less than 1 month	_____
B ☐ 1-3 months	_____
C ☐ 3-6 months	_____
D ☐ 6-12 months	_____
E ☐ More than 12 months	_____

4. How many PCs do you have installed now? _______________
5. Are you a (select one):
   A ☐ End user
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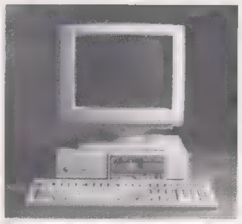

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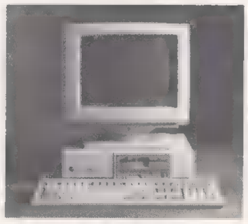
40 MB Super VGA System (800 x 600)	$2,499
100 MB Super VGA System (800 x 600)	$3,099

Prices reflect 512 KB of RAM. 640 KB versions of the above systems [redacted] available for an additonal $50, 1 MB versions for an additional $150, and 2 MB versions for [redacted] additional $300.



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- 1 parallel and 2 serial ports.
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40 MB VGA Color Plus System	$2,099

Prices listed reflect 512 KB of RAM.

640 KB versions of the above systems are available — additional $50, 1 MB versions — additional $150, and 2 MB versions — additional $300. 100 MB hard drive configurations also available.

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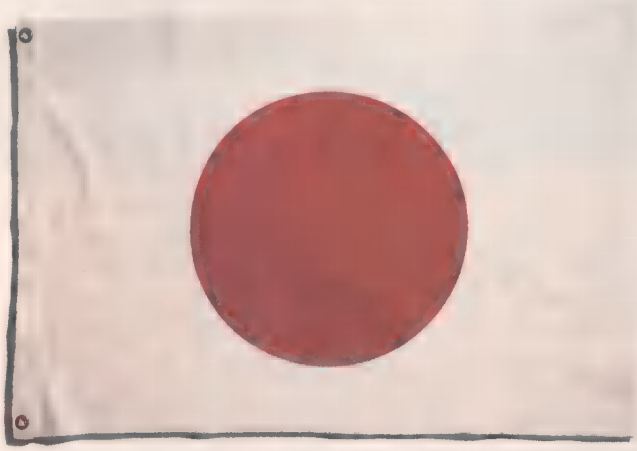

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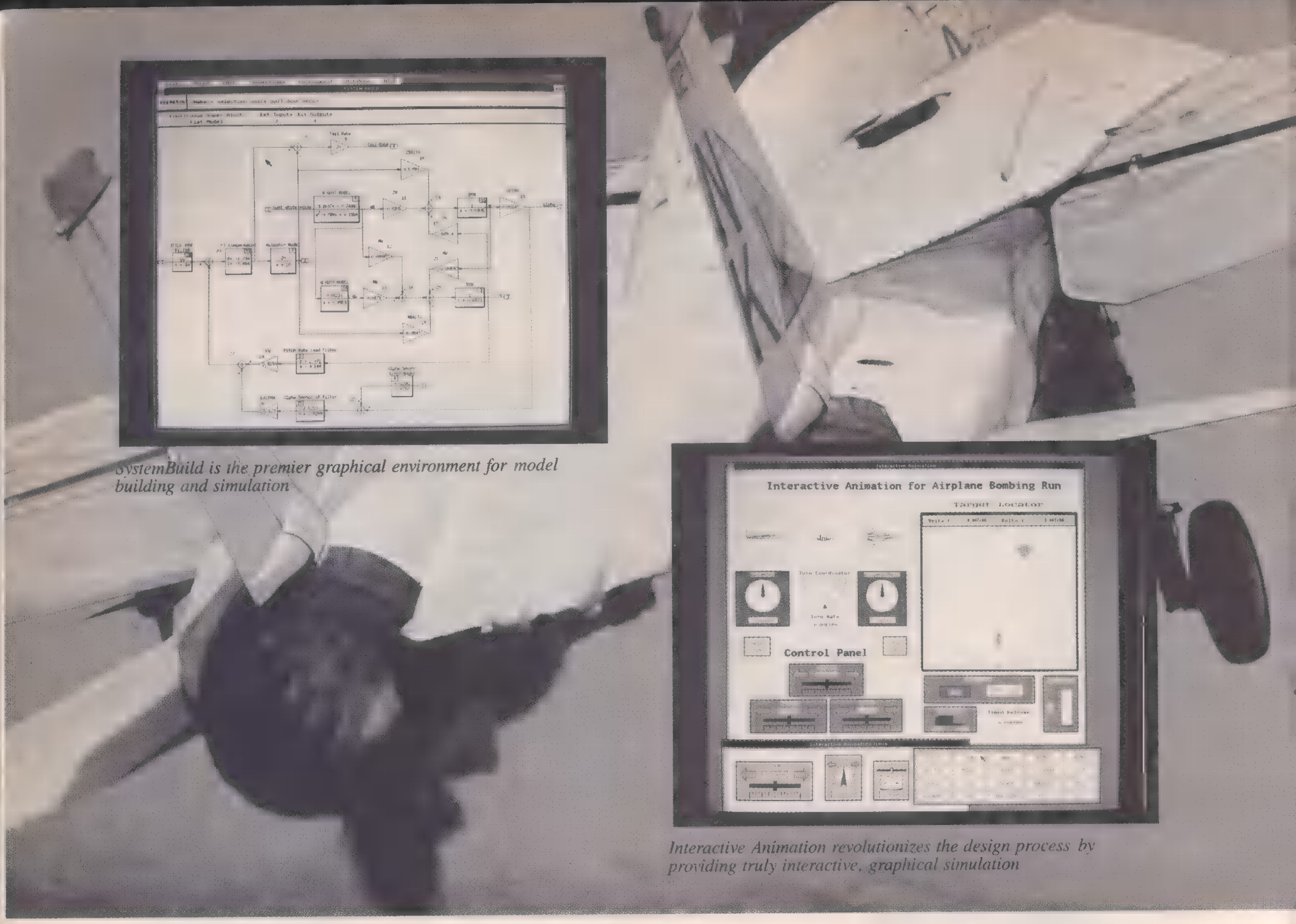

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TECHNOLOGY IN HOLLAND

ASICs Update

A REPORT FROM THE NETHERLANDS FOREIGN INVESTMENT AGENCY

In mid-1989, the Netherlands completed an innovative electronics development program that demonstrated the efficient use of Application Specific Integrated Circuits (ASICs) by 19 small- and medium-sized Dutch companies. This Demonstration Program in Microelectronics has enabled these companies to gain experience in using ASICs and in implementing these circuits in competitive products, ranging from electronic access systems to automobile shock absorbers, for international markets.

Today, the European ASIC market represents a more than $1 billion market which will grow more than 15% annually in the next few years, according to Dataquest. Meanwhile, the Dutch market will be growing in excess of 50% between 1989 and 1992. Here are some of the results of the Demonstration Project that are a part of that growth:

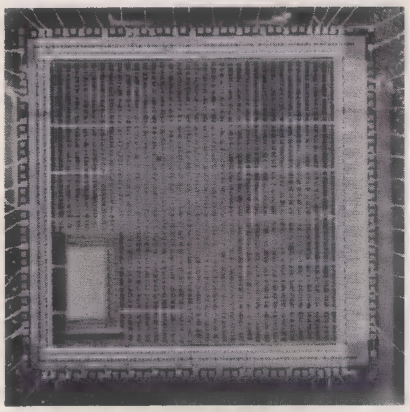
BRONKHORST HIGH-TECH, a provider of electronic sensor systems, developed an analog ASIC for its mass flow meters.

DAHEDI, an electronic systems producer, developed a miniature medical infusion pump controller on a 1.7 sq. inch hybrid circuit with a 2500-gate array.

ECONOSTO, a distributor and manufacturer of heaters and heater-boilers, developed a 2300-gate ASIC for electronically controlling an advanced ceramic heater element to realize both heat reliability and low emission of NO_2.

HYDRAUDYNE, a hydraulic systems manufacturer, developed drive-shaft ASICs to control hydraulic valves.

KONI, a supplier of automobile shock absorbers, developed an EPROM-controlled microprocessor ASIC line for both customer-specified and adjustable shock absorbers.



LIPS, a manufacturer of locks, safes and electronic security systems, developed a full custom CMOS-EEPROM and a 4000-gate HCMOS array for an electronic access system.

NIEAF-SMITT, a producer of electronic measuring instruments, developed a 130-transistor analog-bipolar chip for transducer/multiplier applications in a watt-meter.

NKF-TELECOMMUNICATIE KABEL SYSTEMEN, a supplier of cables and equipment for transmission systems, developed an ASIC for signal processing of video images.

OCE VAN DER GRINTEN, a producer of copiers and office equipment, developed a 3300-gate CMOS ASIC for electric motor control.

DELFT INSTRUMENTS, a manufacturer of advanced optical and electro-optical systems, developed an analog controller chip to intensify the clarity in night-vision binoculars.

PIV ELDUTRONIK, a distributor and manufacturer of industrial drive shafts, developed a PLD-based ASIC for electric motor control.

ROOD MEGATRONICS, a supplier of broadcast studio equipment, developed an analog-digital ASIC stereo-coder for generating a stereo multiplex signal.

SCANTECH, a producer of bar-code laser scanners, developed a two-chip set analog/digital ASIC for control of their slimline scanners used in retail stores.

SPRUYT-HILLEN, a provider of medical disposables, developed an ASIC to control insulin flow through an injection needle.

TULIP COMPUTERS, an IBM compatible PC maker, developed a Clock Parallel and Serial I/O ASIC.

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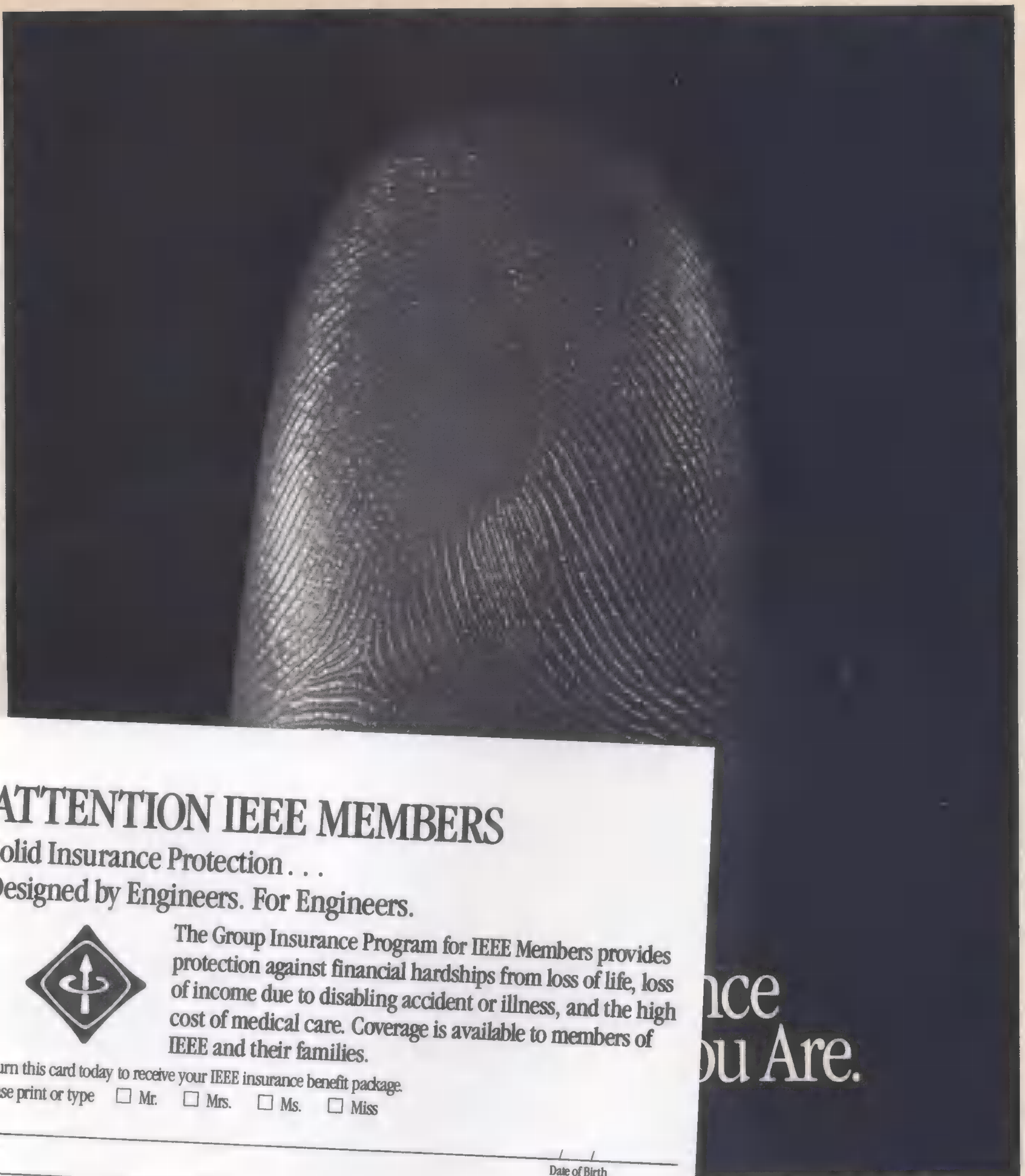

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NUMBER 143

CHILE AIMS FOR NATIONWIDE DIGITAL NETWORK.

Compañía de Teléfonos de Chile, S.A. (CTC) is aiming to double telephone subscribers by completing a nationwide digital network. NEC is supplying the advanced digital switching and transmission systems necessary for this ambitious project.

The core of the network is the NEAX61 digital switching system, which is either already in service or soon to be installed at 127 exchanges with a total of 483,000 subscriber lines. The exchanges are connected in Santiago and neighboring cities with 34MB-to-565MB fiber optic transmission systems and 2MB cable PCM systems.

NEAX61 switches in other Chilean cities will be networked with 2GHz–8MB, 6GHz–140MB, and 8GHz–34MB digital microwave systems. The microwave link uses 50 hops to cover a distance of 1,300km from the Northern border to the Southern end of the South American Continent and across the Strait of Magellan.

CTC is also actively introducing innovative services such as an NEC-equipped cellular telephone system already operating in the Metropolitan Region and Fifth Region. The 800MHz network with 31 cells accommodates a total of 25,000 mobile, transportable and handheld subscriber telephone terminals.

REAL-TIME, 3-DIMENSIONAL MEASUREMENTS.

Making 3-D measurements of moving objects has been a difficult task. Now NEC is developing a simple PC-based system at its C&C Information Technology Research Laboratory.

The Rainbow Range Finder (RRF) uses a triangulation principle to take 3-D measurements. Light emitted from a xenon lamp is diffracted through a grating and projected onto a target object in a rainbow pattern.

The object is observed by a color TV camera with two special optical filters. The camera is installed at a fixed distance from the grating. The precise distance to each pixel of the object is obtained by determining the wavelength of the pixel. Measurements can be made with one TV frame in 1/30 of a second.

RRF is expected to become an efficient tool in factory automation, the fashion industry, surgery and many other applications requiring real-time, 3-D measurements.

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PASOLINK is easily transported and simply consists of a compact outdoor transceiver with antenna, and indoor modulator/demodulator unit.** Communications links are easy to set up and no special shelter or tower is required.

*1.544–44.736Mbps also available. **Not needed for 50GHz use.

NEC

The European Tower of Babel

With the political picture in Eastern Europe changing almost daily, and 1992 and the European Community (EC) inching ever closer, the prospect of a unified Europe is looking possible, if not probable. One obstacle remains, however: language.

Though the idea of all Europeans, or even just those in the EC, speaking a common language is an attractive one, it would be much harder to achieve than creating a common market. The 12 EC countries use nine languages, in which the native speakers feel a fierce nationalistic pride. Picking a common language would be hard enough, but imagine, say, persuading a Frenchman to accept German as Europe's lingua franca . . .

So for many years yet, Europeans will likely have to cope with their multitude of tongues and the problems they can bring. Engineers and others in the electronics industry, however, will probably have an easier time of it than most. Technical language remains quite constant even when transferred from language to language because the new word is often imported along with a new product or concept. Why reinvent the wheel, the Germans must have murmured as they chose to talk about the *Transistor* and the *Diode*.

Some words are not identical in other languages, but the spelling and pronunciation are remarkably similar. For instance, *MOS field-effect transistor* becomes *MOS-Feldeffekttransistor* in German, although *metal oxide semiconductor* (MOS) itself is *Metalloxid-Halbleiter*.

Most of these terms, of course, were coined by English-speaking scientists and engineers. Since World War II, English-speaking countries have dominated technological innovation, so that English now dominates much of the world's technical vocabulary.

Not all countries warm to the English invasion. France takes great pains to maintain the purity of its language and has even formed a government council to keep a sharp eye on the situation. Even so, words like *le microchip* have wormed their way into French—to say nothing of *le Walkman*.

English is especially prominent in Russian technical lingo. *Printer*, *verd protsesser*, *disketta*, *draiver*, and *dzhoistik* are all widely used, according to the *New York Times*. But this linguistic *glasnost* does not stop there: as the Soviets struggle to establish a market-based economy, look for many *biznessmeni* to pursue Western *kompyuteri* and other *tekhnologiya*—and perhaps even issue a *press riliz* trumpeting their successful *dzhoint venchur*.

Words to lay off by

Corporate public-relations departments, especially those in the computer industry, have come up with a dazzling array of vague, unwieldy phrases to refer to the practice commonly known as *laying off workers*. This creative wordplay continues a long tradition of using language to disguise corporate financial problems of many sorts [January 1989, p. 16].

Cray Research Inc. is purging its workforce through *voluntary termination*. IBM Corp. seems to be somewhat kinder and gentler: it asks for *voluntary resignations* from its *population* (Technically Speaking was unaware that IBM had declared itself a geographical entity, although its workforce surely exceeds the population of most towns—perhaps even a small city). And Digital Equipment Corp. calls the severance package it gives to laid-off workers a *financial support option*.

None of these terms is as dispiriting as that used widely in Britain to explain layoffs. There, the worker is informed that he has become *redundant*.

Coordinator: Erin E. Murphy
Consultants: Anne Eisenberg, Polytechnic University; Pamela McCorduck, Columbia University

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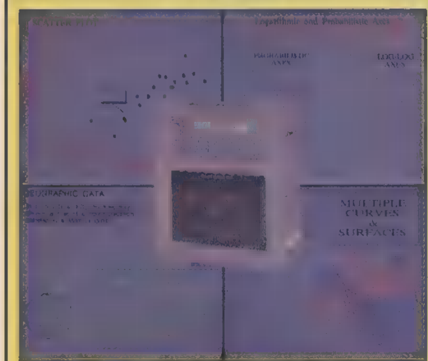

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Circle No. 16

WHATEVER HAPPENED TO...?

V/STOL aircraft

The U.S. Navy has begun planning for the next generation of sea-based aircraft, which could revolutionize naval aviation. Termed V/STOL . . . these aircraft would be capable of operating from most types of naval vessels by taking off either vertically or conventionally within the confines of a comparatively short runway.
IEEE Spectrum, *September 1978*

One of the most challenging goals in aviation is uniting the two great classes of aircraft, fixed-wing and rotary-wing, into a single hybrid encompassing most of the advantages—and few of the disadvantages—of each. It is a challenge almost as old as aviation itself.

Like a helicopter, such an aircraft would take off and land vertically, or at least on a much shorter runway than usual. But once in the air, the hybrid would switch to horizontal flight and cruise with the efficiency of a fixed-wing craft, attaining a range, airspeed, or cargo capacity (or some combination of the three) far beyond any helicopter.

Such hybrids are known by the acronym V/STOL, for vertical or short take-off and landing. The military advantages of V/STOL are obvious: operating from aircraft carriers, small or damaged runways, even a small field, the craft could ferry more men, materiel, or attack weaponry with more speed and efficiency than a helicopter. Since World War II, military aviation agencies the world over have funded studies and development of V/STOL craft; in the United States alone, dozens of prototypes have been flown by all three armed forces.

And though V/STOL has traditionally attracted the military, civilian aviation officials in Japan, Europe, and the United States have begun to feel the lure in recent years, partly because of the need to address congestion at big-city airports. Fleets of V/STOL craft could shuttle passengers between large cities within a few hundred miles of each other: New York–Washington, D.C., for example; or Tokyo–Osaka. With vertical take-off and landing, the craft would not need airports; instead, more convenient locations closer to, or even within, cities could be used.

Nonetheless, V/STOL remains for the most part an unrealized dream. Only one V/STOL craft is in production in the West, the AV-8B Harrier, an attack and air-support jet. Another, the V-22 Osprey, which aviation expert and publisher Jay Miller called "the last great white hope for V/STOL in the next two decades," is now in jeopardy.

The Osprey program is a joint effort between Bell Helicopter and the Boeing Co. in Seattle, Wash. It is the only advanced or next-generation aircraft development effort that Richard Cheney, U.S. Secretary of Defense, has proposed to terminate for budgetary reasons. Miller and others lament the proposal, noting that the Osprey culminates decades of work on V/STOL craft and is the first to have strong prospects in both military and civilian sectors.

Over the years, U.S. designers have experimented with turbo-propeller, jet, and turbojet engines in numerous configurations in their quest for one with enough power and safety. At least one jet-powered V/STOL, the X-13 in the mid-1950s, was launched vertically, off its tail, before rotating 90 degrees for horizontal flight. With other jet V/STOLs, the engines were rotated to change the direction of thrust. This class includes the earliest jet-powered V/STOL, the Bell Air Test Vehicle (ATV), first flown in 1954. The third kind of jet-powered V/STOL changes the direction of thrust through deflection, without changing engine orientation; an early example was the X-14, successor to the ATV, in the late 1950s, while another was the XV-6, a test bed for what later became the Harrier.


Vought Aeronautics Co.

Though jet-powered V/STOL craft have proven useful to the military, their small cargo capacities, relative inefficiency, noise, and high cost make them unsuitable for civilian transport. Thus for V/STOL applications in transport, propeller-driven configurations are the rule. Three important early designs were based on the tilt-wing concept—a wing and propeller that rotate as a single unit. They were the CL-84 in Canada and the X-18 and Vought XC-142 in the United States.

Five XC-142s were built under a tri-service program in the early 1960s [photo]. Although the XC-142 program was scarred by several crashes and fatalities, both the XC-142 and the CL-84 were milestones in aviation, providing researchers with invaluable data on the aerodynamics and operation of large, transport-type V/STOL craft.

Eventually, however, the tiltwing was eclipsed by the other main propeller-driven type, the tiltrotor. The V-22 is the newest and most advanced in this category, a descendant of the XV-3 of the late 1950s. Other tiltrotors include the XV-15, which was the test bed for the V-22. Also influential were the X-19 and particularly the X-22A, a ducted-tiltrotor craft built by Bell Aerospace Textron in Buffalo, N.Y., which logged over 500 flights between 1966 and 1984.

Coordinator: Glenn Zorpette
Consultants: Russell Lee, National Air and Space Museum; Jay Miller, Aerofax Inc.

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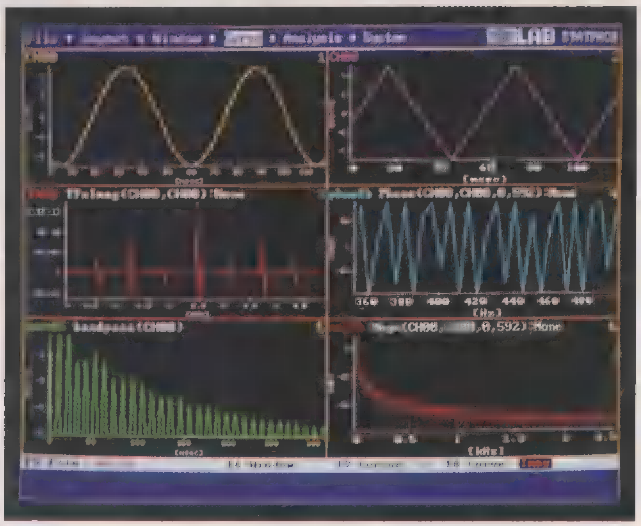

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Shoreham slumbers

Last fall, when *IEEE Spectrum* sent an editorial team and a photographer to tour Lilco's Shoreham Nuclear Power Station on the North Shore of Long Island, N.Y., nearly 500 Lilco employees were at work. But by tour's end, one was left with the impression that the workforce was largely custodial. The highlight of the day for some seemed to be a break for volleyball, played in the expansive but largely empty parking lot overlooking scenic Long Island Sound.

Stephen Gill

The uranium fuel had been removed from the reactor and was immersed in the spent-fuel storage pool, where it still resides. But since the plant remains licensed to operate by the Nuclear Regulatory Commission (NRC), it must follow the safety regulations of any licensed plant, which include requiring visitors to view an indoctrination and safety film before they can tour the dormant facility. Also, workers and visitors must still wear radiation-monitoring devices. And, every two years, emergency evacuation drills covering ■ 10-mile (about 15-kilometer) radius surrounding the plant must still be held.

As we go to press, the Shoreham employee count stands at 380. Workers told us they find the days long and boring. Engineers and operators trained for nuclear power careers are frustrated, some looking for opportunities elsewhere.

Along two walls of a corridor hang some two dozen NRC operators' certificates that would permit each to operate Shoreham, if it could be operated. Outside, a large cluster of temporary buildings, called "contractors' row," stands empty, mute testimony to the bustling activity of the plant's construction period. In the control room, still manned, many of the instruments are tagged "off." (The generator output meter is pictured here.)

Meanwhile, it is estimated that the cost of maintaining the plant in 1990 will exceed $80 million. The town of Brookhaven expects to levy over $70 million in taxes on Lilco for Shoreham this year and says Lilco owes it more than $560 million in back taxes.

Touring the quiescent plant is ■■ impressive as touring the bowels of the *Queen Mary*. It is easy to see where millions of dollars have been spent in customized equipment and controls. The earthquake-proofing alone is an impressive system. Part of it was retrofitted during construction. Also, the control room has been modified and partially retrofitted to bring it into greater conformity with contemporary designs and current NRC requirements.

Still, it is difficult to fathom how $5 billion was spent unless one knows the political travails that accompanied the plant's construction ["The Shoreham saga," November 1987, pp. 24-37; "Lilco contemplates life without Shoreham," October 1988, pp. 20-23].

Over its lifespan, the Shoreham project has been buffeted by every mishap that ■ project of its complexity and magnitude might expect to encounter, including allegations of utility and contractor mismanagement, featherbedding, fraud, quality control lapses, and posturing for political advantage. Its fate finally hinged on the concern whether, in the event of a nuclear release into the atmosphere, the affected citizenry on Long Island could be safely evacuated.

If, ultimately, decommissioning should be Shoreham's fate, ■ shutdown cost exceeding $350 million can be expected. Mario Cuomo, governor of New York State, has urged that part of Lilco's budget for research and development be redirected to help finance decommissioning, if that should be the decision.

The project—indeed, Lilco itself—had been threatened with takeover by ■ state agency, and in April 1989, Lilco signed an agreement with the State of New York to sell it the controversial plant. In return, the New York State Public Service Commission guaranteed three years of rate increases to Lilco, which projected over 10 years would amount to 63 percent.

How could an enterprise of Shoreham's magnitude be funded, designed, and completed in light of the uncertainty of its ever operating? If ■ bright note can be found in the saga, it may be that only in a democracy could such ■ chronicle of events occur. The cost of the plant, whether it runs or not, will be borne by the citizens, and the due process by which the decision is made will be conducted substantially under public scrutiny. Nevertheless, one at least hopes that the lessons of Shoreham may prevent ■ rerun elsewhere of the costly scenario. [A portfolio of Shoreham photographs taken by ■ *Spectrum* photographer during the September visit appears on p. 46.]

Telephone trials and triumphs

Putting a telephone in an unprotected environment is begging for trouble, ■■ many hopeful callers searching for ■ working telephone on the streets of New York City well know. When *Spectrum* pursued research for ■ new series on the postdivestiture U.S. telephone system [p. 25], we found that among forbidding environments for public telephones, New York City is known as having the worst and, therefore, can serve as the best laboratory for several dozen companies that hope to contest for a piece of the deregulated business.

On the positive side, technology has enabled the number and types of customer services to burgeon. Yet on the streets or in the home, these service options face their own hurdles—functional ■■ well as legal and ethical ones.

These include the challenges of user-friendly programming, standardization, and equitable rates. A good example of ■ controversial feature that may end up in the courts is automatic caller identification.

These and other topics will be covered in the new series.

—Donald Christiansen

New pay phones hit the street

The Federal Communications Commission opened the market to competition six years ago, ushering in new players, technologies, services—and confusion

The following is the first of a series on technical advances and changes in the regulatory climate in U.S. telephony since the court-ordered divestiture of the AT&T Co. six years ago. —Ed.

The public telephone, a fixture on the U.S. landscape for 101 years, is in the midst of a radical transformation. New kinds of pay phones, made by small, competitive companies, are pushing the state of the art in a technical ferment that has bred more service offerings. Soon, for example, a variety of equipment made by many different manufacturers will let users send voice, data, and facsimile messages through public terminals.

As might be expected with any such upheaval, the changes have been confusing, to telephone companies and users alike. As public telephones become more complex, the already difficult task of repairing and maintaining them could begin to overwhelm telephone companies, particularly in areas like New York City, where pay phones—and vandalism—are ubiquitous [see "On the front lines of the pay phone war at New York Telephone," p. 30].

For those who use public phones, the situation is already trying. Once able to count on the same kind of telephone and service almost everywhere in the country, they are now confronted with a bewildering variety of telephone sets, services, operators, and, perhaps most important, rates.

"I don't think most consumers understand what's going on," said Tony Stephens, director of public communications for GTE Telephone Operations in Irving, Texas. "There's frustration and uncertainty. I think sometimes people don't really know if they're using one of our pay phones or a private pay phone."

One problem is that the long-distance rates incurred using a private company's pay phone may be higher than those of a pay phone operated by a public telephone company. However, any month now, the U.S. Congress is expected to approve legislation that would make it harder for operators of private pay phones to charge what many consumers feel are exorbitant rates.

The sweeping change in public telephony is a result of a 1984 Federal Communications Commission (FCC) decision to open the pay telephone market to competition. For the first time, public telephones could be owned by organizations other than the local-exchange telephone company. Within months, some 100 companies registered with the FCC to supply telephones for the new market, although four companies now control most of the business. What they make goes by different labels, such as a private pay phone (PPP) or a customer-owned, coin-operated telephone (COCOT). Literally anyone can buy one and go into business. Most, though, are owned by specialized telecommunications vending companies formed to exploit the opportunity created by the FCC decision.

Since the first PPPs were installed late in 1984, the growth of the industry has been impressive. About 225 000 PPPs are now installed in the United States, according to William S. Moorhead, chairman of Public Communications Investments Inc., a venture-capital and consulting firm in Washington, D.C. For comparison, about 1.9 million telephone-company–owned pay phones are located throughout the country.

Reliable figures on the PPP industry's annual growth rate nationwide are difficult to confirm. Moorhead estimates future growth at about 3 percent a year, barring any significant regulatory changes, while other groups, such as the North American Telecommunications Association in Washington, D.C., have estimated annual growth to be as high as 64 percent.

Roughly one-half of the private pay phones now being installed are sold by one company: Intellicall Inc. of Carrollton, Texas, according to Moorehead. The other three major suppliers, in descending order of size, are: Elcotel Inc. in Sarasota, Fla.; Ernest Telecom Inc. of Norcross, Ga.; and Protel Inc. in Lakeland, Fla. AT&T Co.'s Consumer Products Division in Parsippany, N.J., also offers a PPP, but the communications giant has yet to match the sales of the other companies in the intensely competitive field.

Fourier voice check

Like the traditional local-exchange carrier's pay phone, PPPs provide local and long-distance service, are reasonably rugged and weatherproof, and can be operated in exchange for coins or credit. But there the similarities end.

The traditional phones, costing between $500 and $850, rely on facilities of the telephone company for many functions, including rate computation, credit card verification, connection of collect calls, generation of operator messages, prompts, and tones. Lacking the services of the local phone company, however, private pay phones, which cost anywhere from $800 to $2000, must perform all of these functions—and more—by themselves, typically through the use of dedicated 8-bit microprocessors and custom software.

Surprisingly, the most difficult function of all is answer supervision (determining when the remote party has answered the telephone), according to Alvaro R. Quiros, president and founder of Elcotel. Answer supervision is especially critical because it determines whether, under certain circumstances, the phones will erroneously bill users for calls not completed, a blunder that happened frequently after the first PPPs hit the street.

Elcotel's basic approach is to listen for the moment when "ringback" ends and voice communication begins. Ringback, the sound heard by the caller as the remote phone is ringing, is standardized throughout most of the United States as 2 seconds of ringing followed by 4 seconds of silence. The telephone must distinguish ringback from a busy signal—one-half second of buzzing followed by one-half second of silence.

The exceptions to these conditions are numerous, however, and must all be taken into account. A telephone in a noisy hotel lobby, for example, may present the telephone's processor with both ring-

Glenn Zorpette Associate Editor

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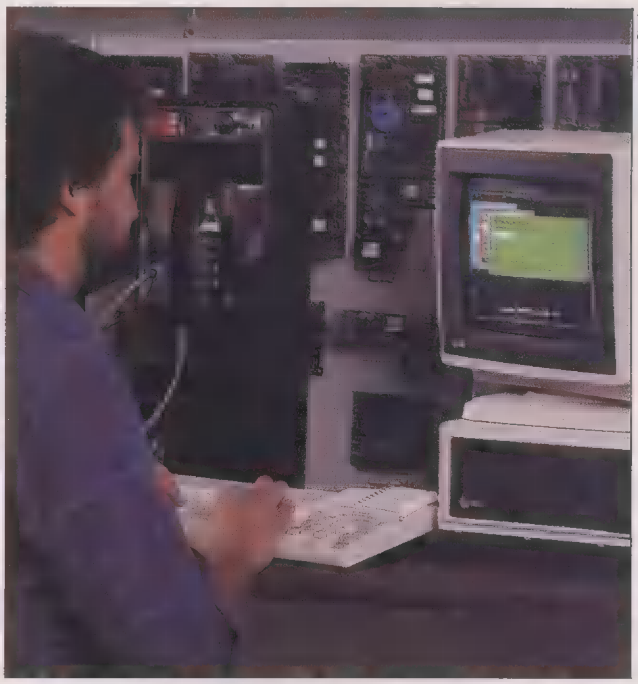
back and background voices; Elcotel prevents this possibility by closing the telephone microphone until the distant party answers. A number that is not in service will typically respond with a standard recorded message, which the telephone must distinguish by its special information tones (SIT): three notes before the standard operator message stating "the number you have reached is not in service at this time." Other potential troubles are posed by aging central office equipment, which may cause clicking noises or static on the line.

To prevent such noises from being interpreted as voice, Elcotel does rudimentary Fourier analysis of the received signals within its phones before classifying them as voices, according to Quiros, an IEEE member who designed his company's first telephone. Elcotel's algorithms have been so successful, he said, that the company is now packaging them for sale to hotels, hospitals, and other institutions for their private-branch exchanges (PBXs).

Another interesting challenge faced by PPP designers was finding a way to automate collect calls so that they could be completed without the assistance of a human operator. That solution was inspired by studies done by Bell operating companies, particularly Southern Bell in Atlanta, Ga. After checking the caller's credit card and verifying that the number being called is viable, the telephone makes a digital recording of the caller's name. After the call is completed, another recorded message informs the called party that he or she has a collect call, and the recorded name is played back for identification.

The called party can then accept or reject the call by pressing a one or zero on a touch-tone keypad. Since not all telephones have such pads, several companies, including Elcotel, are working on speaker-independent voice-recognition algorithms that will recognize the called party's spoken "yes" or "no" in response to the recorded prompt.

A similar function, and the latest feature to be tested in both telephone-company and private pay phones, is voice messaging. After a pay phone user receives a busy signal, a digitized voice then asks if he or she would like to leave a message for the busy party. If the answer is yes, hardware at the central office (or in the private pay phone itself) records the caller's brief message. Calls are placed automatically at regular intervals, typically every 15 minutes for 2 hours, until someone answers, at which point the message is played back. GTE and several other telephone companies are now testing the service to determine, among other things, how much users are willing to pay for it.



Allen Steele

Don Adams, a validation engineer with Elcotel Inc. in Sarasota, Fla., tests software that lets a user manage a network of pay phones remotely, through the use of a modem. The program, called expert editor, runs on IBM-compatible personal computers and offers a series of colorful menus to simplify the process of altering the pay phones' operating software to reflect new rates, calling procedures, or other changes.

Intense competition

As such algorithms attest, the level of technology in private pay phones is advanced. And with industry trend setters like Elcotel and Intellicall constantly striving to outdo one another, PPP technology has become one of the most fertile, rapidly advancing segments in the telecommunications industry.

For example, microprocessors in the Elcotel and Intellicall phones function as embedded controllers, responding to inputs such as dialing and credit card information with appropriate responses: validating the credit card number (which itself may require a quick call to a verification service) and connecting the call, say, or playing a recorded message notifying the user that the number dialed or credit card used is invalid. All information regarding the call—duration, time of day, and number called—is stored on nonvolatile RAM, so that a loss of power will not result in a loss of any billing records.

In the companies' first models, rate tables were stored on programmable read-only memories that had to be customized for every location where a phone was installed. Any changes in rates required a new set of programmable ROMs, the installation of which had to be done by hand in all of the phones, a time-consuming process.

Both companies in their most recent versions have replaced the PROMs with EEPROMS and battery-backed RAM, so that rates can be changed remotely, over the phone lines, by using a simple personal computer equipped with a modem. In fact, the upgrades possible in this manner are not limited to rates. For example, if an operator wanted to modify his or her phones so that they could access another long-distance carrier, this software change could also be downloaded through the lines.

The system is not limited to one-way communications, either. Operators can use the PC and modem to interrogate their phones for such in formation as how much money is in the coin boxes, when the last call was made, how many calls were made in the last 24 hours, and whether the phones are experiencing any problems. Phones can also act as their own alarms, sending a message to the PC to report damage the instant it happens. In addition, all billing records from credit card calls can be gathered by the PC via the phone lines.

Transferred to a floppy disk, the billing data are sent to the pay phone manufacturer for processing, typically by a third party, so that the charges show up on the user's telephone bill. Thus, the number of parties that may share in the profits from any given telephone are many, including: the owner of the phone; the owner of the property where the phone is located; the manufacturer of the phone; the third party that handles billing for the manufacturer; the local telephone operating company, which generally charges a tariff; and the long-distance carriers used to complete those calls.

A more recent technical competition is in the use of low-power components, and here Elcotel appears to have bested, at least for now, its larger rival Intellicall. Through extensive use of CMOS chips and conservative use of power-hungry circuits, Elcotel has built a PPP powered only by the 23 milliamperes of the standard line from the central office. Models from Intellicall and most other PPP makers, on the other hand, require a 110-volt ac line for power.

Rates rile

But while manufacturers fine-tune their product technologies, the U.S. Congress, various state regulatory bodies, and the Federal Communications Commission are grappling with the much

thornier challenge of how best to regulate the private pay phone industry.

The outcome of bills now before Congress, and of issues being considered by the FCC, could be critical to the industry, according to venture capitalist Moorhead, who is also an attorney.

Those most likely to be immediately affected are PPP owners and firms providing alternative operator services (AOS). The latter organizations have human operators assisting PPP users when necessary. Intellicall has its own AOS setup, although most other AOS companies are independent.

On the front lines of the pay phone war at New York Telephone

New York City is nothing if not a city of extremes, and it is no different with public pay telephones. There are 58 000 of them in the city's five boroughs. "The density of public phones on the street, per capita, is much higher than anywhere else in the world," said Robert E. Bellhouse, general manager of public communications at New York Telephone.

Statewide, New York Telephone operates 122 000 pay telephones, 93 000 in the area south of Albany. In that area, 93 000 keys—one for each pay phone—open boxes that yield about $800 000 in coins every day. In the city, New York Telephone's 8000 street pay phones (the other 50 000 are in lobbies, hotels, or otherwise sheltered) produced 160 000 problems in 1989, 59 percent of which were due to vandalism.

In his office in Manhattan, Bellhouse displayed a few casualties: a phone with its coin box cut out, another with its handset cord severed, yet another unit completely destroyed, apparently by a sledge hammer. "We have an endless supply of this stuff," he mused. "If you apply enough kinetic energy to anything, you'll break it."

Last year, there were only 250 arrests made in connection with the 94 000 incidents of vandalism, which cost New York Telephone more than $10 million. "My perception is, vandalism is worse in New York City than anywhere else," said William S. Moorehead, a national telephone consultant and venture capitalist based in Washington, D.C.

New York Telephone has begun to exploit technology to catch up with the damage. Roughly 12 percent of its pay phones in the state are equipped with microprocessor-based internal-diagnostic circuitry, which automatically places a call to a host computer in an operations center when damage or some other problem occurs. The message sent classifies the problem as one among 11 different trouble conditions. The message passes through the host computer to a maintenance computer, and then to a dispatch center, from which it is passed on to a company maintenance worker. The company hopes to have the diagnostic circuitry on 30 percent of its pay phones by the end of the year.

Still, a maintenance force of 1000 has not proved sufficient in some areas. New York Telephone declined to release the current percentage of city pay phones not working, but records made available to *IEEE Spectrum* by the New York State Department of Public Service indicate that the number sometimes reaches 20 percent in some exchanges. Although for budgetary reasons the department no longer does preannounced inspections of pay phones, it still receives from New York Telephone monthly reports of percentages of nonworking phones in various districts. If the level exceeds 20 percent for three consecutive months, the department demands a formal report explaining the problems and the proposed solutions, said Edward S. Collins, a spokesman.

Gunter Knop (photos)

According to the department's records, more than 20 percent of pay phones were not working at some time between Feb. 20 and March 20, 1990, in 11 of the 63 telephone exchanges with pay phones in Manhattan and the Bronx. But such figures only tell half of the story. Nonregulated, privately owned pay telephones often outnumber operating-company phones in inner-city areas, and the privately owned pay phones in New York City are generally not as well maintained as those operated by New York Telephone, according to Thomas J. Dunleavy, deputy director for telecommunications of the New York City Energy and Telecommunications office.

Said Glenn Williams of Community Board No. 11 in the East Harlem section of Manhattan: "In neighborhoods like this, there are problems finding phones that work." Commuters in the city's main transportation terminals, Grand Central Station, Pennsylvania Station, and Port Authority, often have the same complaint.

But vandals are not all that bothers Bellhouse. He must also contend with more sophisticated thieves who use slugs, fraudulent credit cards, or other means to make calls without paying for them. He recalled an episode of a popular television program in which the star actor demonstrated, in effect, a way of making a real pay phone work without putting money in it. The method also damaged the phone and Bellhouse saw his annual expenditures for fixing the kind of vandalism depicted go from $300 000 before the broadcast to over $2 million afterwards.

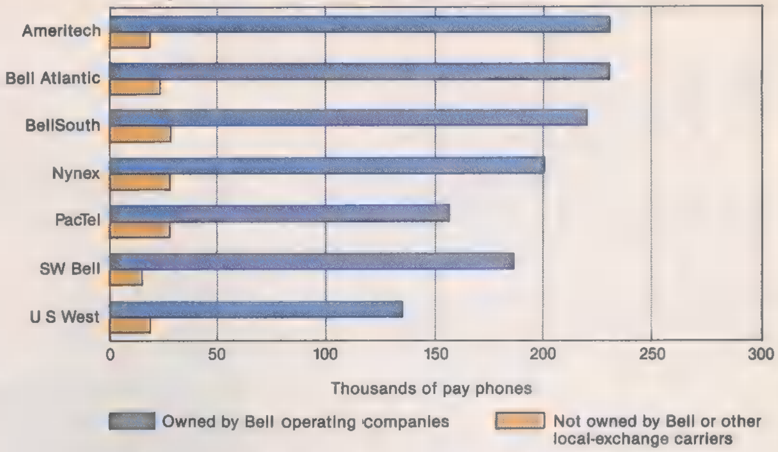
Another constant chore is trying to keep pay phones from becoming, in Bellhouse's words, the "poor man's ATM" [automatic teller machine]. For this, the latest equipment ranges from a thick new steel alloy plate designed for installation over pay phone coin boxes to a new coin detector, built by Mars Electronics in Westchester, Pa. The coin detector, designed to New York Telephone's specifications, is entirely electronic, identifying coins by their characteristic deformations of a magnetic field, rather than their weights and sizes.

Not all of the advanced technology in public telephony is going into the pay phones themselves. To keep track of its vast coin-collecting operation, New York Telephone is now converting to a highly automated system, in which computer programs predict when telephone coin boxes will be full. Two days before that date, a robotic assembly fetches keys to those coin boxes, verifying the keys by holding them in front of video cameras [photo, left]. Counting the tidal wave of quarters falls to 28 high-speed machines [photo, above], specially designed and built in Switzerland. —*G.Z.*

The problem dates to the birth of the AOS industry. Some entrepreneurs in the new field, eager to recoup their investments as quickly as possible, charged exorbitant rates for credit-card calls. According to Consumer Action and the Telecommunications Research and Action Center, both consumer advocacy groups in Washington, D.C., charges for AOS-assisted calls made with private pay phones were, in some isolated cases, 500 times more expensive than comparable calls made via AT&T on a telephone company pay phone.

In July 1988, the two advocacy groups filed a formal complaint with the FCC against five of the largest AOS companies, which at the time were: International Telecharge Inc., National Telephone Service Inc., Payline Systems Inc., Telesphere Network Inc., and Central Corp. (which has since filed for organization under Chapter 11 of the U.S. Bankruptcy Code). The FCC estimates that there are between 60 and 100 AOS companies, although the group's own lobbying organization puts the figure closer to 200.

1988 penetration of Bell pay phone market



Source: North American Telecommunications Association Market Research Department estimates

Since the U.S. pay phone market was opened to competition six years ago, private operators of pay telephones have had varying degrees of success in penetrating the service territories of the seven regional Bell operating companies. The extremes are represented by Pacific Telesis in Nevada and part of California, where 17.7 percent of the pay phones are non-Bell, and Ameritech in the north central United States, where just 7.86 percent are operated by private concerns.

Although the days of rates inflated to 500 times those of AT&T's are over, costs between two and four times those of telephone-company–AT&T calls persist, according to John Windhausen, majority counsel for the Subcommittee on Communications of the U.S. Senate Committee on Commerce, Science, and Transportation.

As of February 1990, the FCC had received 4000 written complaints from consumers regarding AOS-assisted calls, according to Thomas Wyatt of the commission's common-carrier enforcement division. Complaints come in steadily at a rate of about 125–150 a month, Wyatt added.

Two bills before the Senate would force owners of PPPs to identify clearly, on every phone, which AOS the instrument is connected to, and inform users of their right to choose a carrier other than the one the telephone is connected to. The phones would also have to display a telephone number for information on rates for long-distance calls.

That legislation would also put an end to "blocking," a practice considered particularly nefarious by consumers, which makes it impossible for a pay phone user to access certain long-distance carriers, such as AT&T or U.S. Sprint. In effect, it ensures that most calls are handled by whichever carrier the phone is connected (presubscribed) to, often an AOS. It occurs regularly in some regions, according to the FCC and Congressional sources, despite having been declared unlawful by the FCC in response to the formal complaints made in July 1988.

Another common consumer complaint involves splashing, also known as forward splashing. It works like this: a person using a PPP in Kansas City, Mo., calls a number in St. Louis, using the services of an AOS. The caller asks to be transferred to AT&T, but does not know that the AOS is based in Dallas and that he or she is being connected to an AT&T operator there. Thus the AT&T operator, unaware of the situation and unable to rectify it in any case, bills for an interstate, long-distance call from Dallas, rather than a relatively inexpensive call within Missouri. Unfortunately for the user, the situation does not become clear until the telephone bill arrives. "It's still happening," said Windhausen.

Mainly because of unresolved problems like blocking and splashing, the states of Alaska, Arkansas, Connecticut, Oklahoma, and Hawaii have banned PPPs.

The difference between the two bills, S.1660 and S.1643, is that the latter would penalize AOS companies and PPP owners and operators caught blocking or splashing. The bill, introduced by Senator Alan J. Dixon (D-Ill.), would prevent the owners from receiving commissions from AOS companies, and force AOS companies that engage in blocking to charge the lowest rates of all carriers then prevailing in the area.

"The FCC order of February 1989 is basically being ignored," said Bill Kolloff, a member of Senator Dixon's staff. "A year's gone by, and we're still getting 150 complaints a week. Senator Dixon feels it's about time we put some teeth into the legislation."

Coming: digitals

As Congress debates future legislative controls, technical advances keep coming. Over the next few years, many of them will be related to operation of nascent integrated-services digital networks (ISDN).

Telecommunications specialists such as Richard Peck, a district manager at Bell Communications Research in Livingston, N.J., see ISDN as the possible key to a new world in public telephony, one in which information is exchanged as easily as voice. The next step in this plan would be the installation of public data terminals, complete with cathode-ray-tube monitors, in airports and railway stations. Users could access stock information and the latest news, or make travel reservations. Travelers to Denver, for example, could check weather reports for that city, investigate ski conditions and entertainment opportunities, and read restaurant reviews.

With the advent of ISDN, a businessman could use the monitor to look at documents from his home office, while using the other line to make changes or to discuss the documents with coworkers.

But New York Telephone, for one, is not waiting for ISDN before it tests the concept. Later this year, it plans to put a series of Public Information Access Terminals in transportation centers. Each will have an internal microcomputer based on an Intel 80386 microprocessor. A gateway program called Info-Look will guide users as they make airline or hotel reservations, catch up on news with the Nexus service, or query a database back home.

To probe further

Public Communications magazine is the main industry journal, covering matters of interest to both private operators and operating companies. The magazine is published by Information Publishing Corp. in Houston, Texas. Shortly before it ceased publication, *High Technology Business* published "Pay Phones Pay Off," an enthusiastic description of the private pay phone industry, in the November-December issue, pp. 24–27.

Magnetic megabits

Improvements in recording densities are allowing magnetic storage to pack even more data than its optical cousin

ADVANCED TECHNOLOGY
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Proponents of optical storage have always emphasized its high bit density, which, they say, will be key to its winning a share of the data storage market from magnetic recording technology. After all, there is no magnetic equivalent to the focusing action of an optical lens. To the contrary, the density of magnetically recorded bits is limited by the size of the read/write head and its separation from the recording medium. In short, despite advantages in other ways, magnetic storage has always been one to two orders of magnitude below optical storage in terms of bits per square millimeter.

But things are changing. Recently, a magnetic disk was demonstrated with over twice the bit density of current optical recording. The feat involved two major technology innovations: a highly sensitive magnetoresistive head and an advanced signal-detection technique. Also essential was an ultralow-noise disk, an improvement that emphasizes how important incremental changes continue to be in advancing magnetic recording technology.

Computer applications and consumer electronics have been the two chief areas spurring progress in the field. While equipment and techniques differ markedly, there are numerous examples of technology from one area influencing the other. For example, the metal-in-gap heads first found in 8-millimeter videocassette recorders (VCRs) are now appearing in some high-capacity 5-1/4-inch disk drives. Conversely, the trend toward the use of thin-film metallic media, well-established in the rigid-disk field, is shifting to videotapes, as in the new Hi-Band 8 Camcorder format.

In many cases, audio and video signals are now being recorded digitally, lessening the distinction between traditionally analog consumer and professional electronic products and digital computer and data storage equipment. In both applications, sophisticated signal processing is needed to ensure reliable data recovery at the highest bit densities.

Beyond ferrites

The benchmark for comparing new heads is the conventional ferrite head used in most VCRs and disk drives. It is constructed by winding several turns of wire around a yoke made of ferrite, an oxide of iron and other metals. A current passing through the wire creates an intense magnetic field in the narrow gap in the yoke. The field can be used to write tiny magnetized regions onto a recording medium. To play the information back, the head, the medium, or both are moved, altering the magnetic flux threading the ferrite yoke, and inducing small voltages in the coil.

Ferrites have superior high-frequency behavior and good tribological (wear and frictional) properties. But ferrite heads produce too weak a field to record well on very high-coercivity media, which can support higher recording densities. Coercivity measures the field required to reverse the direction of magnetization of a recorded region in the medium. Consequently, higher-coercivity media are less likely to demagnetize, a critical design factor where tiny regions of alternating magnetization must be packed together.

Some alloys of ferromagnetic metals (iron, cobalt, and nickel) can support fields two to three times as intense as ferrite can. However, in high-frequency applications, a head made entirely of metal would be subject to eddy currents that would prevent magnetic flux from penetrating it. To reduce this problem, heads may be laminated with an insulator like alumina. Alternatively, the metal may be limited to a small critical region in an otherwise conventional ferrite yoke, the approach labeled metal-in-gap (M-I-G). These heads can write to a medium with much higher coercivity than can a head made of ferrite alone. Originally adopted by Sony Magnetic Products Inc., Miyagi, Japan, and others for video and rotary digital audio tape (R-DAT) applications, the M-I-G head has recently become popular for high-capacity 5-1/4-in. rigid-disk drives.

An M-I-G head has a thin, micrometer-thick layer of metal on the trailing side of the gap, close to where the data is actually written to the medium. The metal used is often Sendust, an alloy of aluminum, iron, and silicon. But because the yoke is still mostly ferrite, it exhibits good high-frequency response.

The most difficult aspect of developing M-I-G heads has been to ensure that the interface between the metal and the ferrite is magnetically continuous. Otherwise, severe playback distortion can occur from a pseudo-gap where the different materials meet. These difficulties have been largely overcome by introducing a

Defining terms

Areal density: amount of information stored per unit area, measured in bits per square millimeter.
Coercive force: the magnetic field required to write or change the magnetization pattern in the recording medium.
Energy product: approximately remanence times coercive force.
Remanence: the level of residual magnetization that can be stored in the recording medium.
Slider: in rigid-disk Winchester technology, the small rectangular "slider" of ceramic or ferrite, on the back of which the recording head is mounted. As the disk starts rotating, the carefully designed "air-bearing" surface on the slider allows it to start flying at a separation of less than a micrometer from the disk's surface.
Transition separations: the distance between two magnetic transitions. A magnetic transition is the change in magnetization between two oppositely magnetized bit cells. It is the magnetic field from the transition that is picked up by the head.
Tribology: the science that studies surfaces moving against each other—a drive head in relation to the magnetic medium, for example.

Roger Wood IBM Corp.

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barrier layer that prevents the Sendust from diffusing into the ferrite and poisoning it magnetically. And M-I-G heads in 5-1/4-in. high-performance drives are competing not only with conventional ferrite heads, but also with the widely used thin-film metal heads, which still hold an advantage in manufacturing tolerances and in reading at high densities and high data-rates. Thin-film heads, used extensively in high-capacity disk drives, are formed photolithographically by depositing thin layers of metal on a thick ceramic wafer that is then diced and machined into hundreds of individual heads.

Big signals

The new head technologies are being driven by the need for higher recording densities. As the size of the recorded bits shrinks, so, too, does the signal produced by the head. These small signals are easier for magnetoresistive than conventional heads to read. The voltage output from an inductive head drops linearly as the bit area gets smaller. But for a magnetoresistive head, the geometry and sense current (used to measure the resistance) can be carefully optimized, so that output drops much less as the bit area shrinks.

In contrast to an inductive head, whose output voltage is directly proportional to its speed relative to the medium, magnetoresistive output is governed only by flux intensity. This is an advantage for low-speed applications: for instance, in the reading of credit cards, in which the card is moved slowly across the head.

The magnetoresistive head makes use of the slight changes in resistance that occur as the magnetized data bits passing beneath it change the angle of magnetization in its magnetoresistive element [Fig. 1]. This element is sandwiched between two magnetic shields that reduce sensitivity to stray fields and are only placed a short distance apart, to achieve the short-wavelength resolution needed for high-frequency output.

Since the magnetoresistive head can only read, writing requires a separate, inductive head. This drawback can, however, be turned to the designer's advantage if the write head is made wider than the read head. The read head then has more freedom to move in the wider written track, reducing mistracking effects.

Many companies market magnetoresistive computer tape heads. But none has yet been incorporated in a commercial disk drive, although a recent acquisition (PCI) of Seagate Technology Inc., Scotts Valley, Calif., has been offering samples for disk-drive use for some time. The relative fragility of magnetoresistive heads and the additional complexity of combining them with an inductive write head present major design challenges. It is also hard to ensure that only a single, stable magnetic domain will exist in the sensor. The output voltage becomes unpredictable if two or more domains form.

Nonetheless, a magnetoresistive head was a key component in a high-density rigid-disk demonstration by the IBM Magnetic Recording Institute of San Jose, Calif. This demonstration achieved a storage density of over 1.8 million bits per square millimeter, with on-track error rates of less than 10^{-9}.

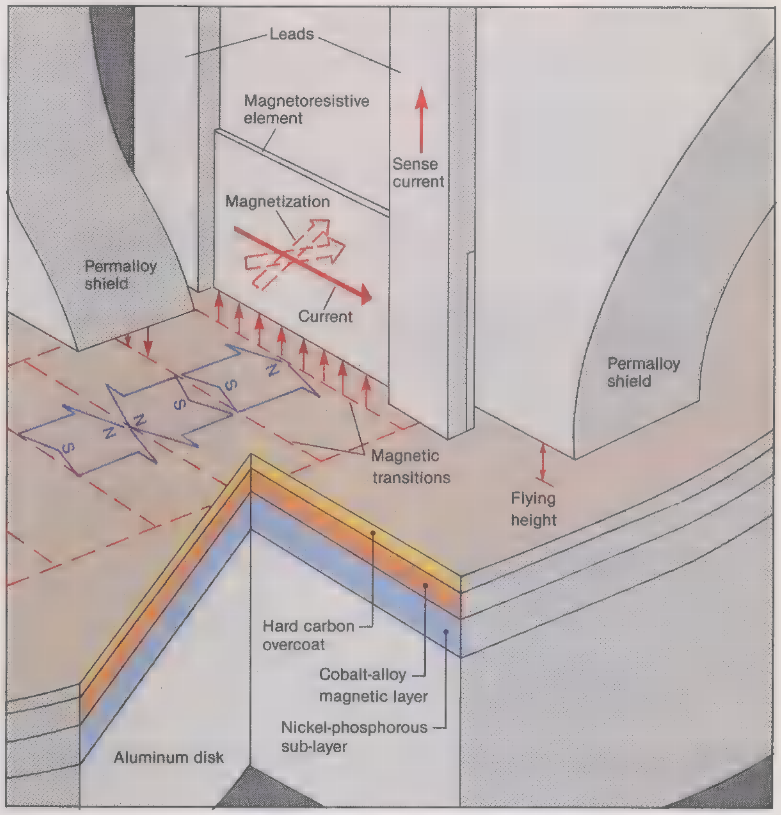
As a basis of reference, IBM's current high-capacity drive, the 3390, records at 100 000 b/mm^2; erasable optical sytems record at 400 000–700 000 b/mm^2; and even the compact-disc ROM, or CD ROM, a read-only device, records at less than a million bits per square millimeter, of which 25 percent is allocated to error correction to combat on-track error rates of about 10^{-5}.

At the densities demonstrated, the written track-to-track separation is about 3.4 micrometers and the bits are some 160 nanometers long. The shielded magnetoresistive head flies as little as 60 nm above the disk surface.

As with other recent prototypes of magnetoresistive heads, IBM's head was made from permalloy, a nickel and iron mixture. The metal is preferred for magnetoresistive heads because of its high magnetoresistive coefficient: a relatively large change in resistance, up to 2.5 percent, is produced as the angle between magnetization and current changes.

IBM has yet to announce commercial plans for the technology in a disk drive. However, a disk drive storing data at these densities is considered feasible, though some design challenges re-

(Continued on p. 36)



[1] The magnetoresistive head of a rigid disk, like the one in a demonstration by IBM, with 1.8 million bits per square millimeter, relies on changes in resistance to sense the magnetic data in the disk. A single magnetic domain in a very thin magnetically soft film is the heart of the device. The resistance of the thin-film element changes with its angle of magnetization. The element is usually made of permalloy, a mixture of 80 percent nickel and 20 percent iron, because it offers a large resistance change of over 2 percent. Changes in resistance are sensed by using the leads to pass a current through the element. The maximum current is limited by electromigration of the permalloy.

Typically, the magnetoresistive element is sandwiched between two magnetically soft shields, which serve to define and enhance the resolution and also protect the element from stray fields. Magnetic flux from the data in the disk (the arrows with the north and south poles) is picked up along the element's lower edge. The angle of magnetization in the element changes as it conducts the flux, which eventually returns to the disk through the shields. The magnetization in the element must be carefully biased to about 45 degrees, where resistance versus flux is approximately linear. Also, the element must contain only a single, stable magnetic domain, or its output becomes unpredictable.

The head is flying about 100 nanometers above the surface of a thin-film rigid disk. The film is usually a cobalt alloy about 25 nm thick protected by a similar thickness of hard carbon overcoat. The raw aluminum disk is first turned on a lathe using a diamond tool before being plated with several micrometers of electroless nickel-phosphorus, a material that can be readily polished to yield a very smooth, flat surface.

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Chairman of the Board & CEO
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[2] Transmission electron micrography has magnified by 230 000 times the differences in microstructure between a metal-evaporated and a VHS tape. The curved columnar structure of the finely grained evaporated metal film (above) and its corresponding magnetic anisotropy closely match the orientation and curvature of magnetic field lines from the head, a factor responsible for the tape's very high resolution. By contrast, the VHS tape (below) made of iron oxide particles embedded in plastic, has a higher degree of granularity, which diminishes resolution and gives a poorer signal-to-noise ratio. The energy product of VHS tapes—defined approximately as remanence multiplied by coercivity—is only a quarter that of metal-evaporated tapes. As a result, relatively large particles are needed to ensure magnetic stability.

(Continued from p. 33)
main. Although the heads, disks, and detection circuitry can be made, there is some catching up to do to sustain track densities of 300 tracks per millimeter and flying heights of 60 nm. Tolerance in on-track head positioning would have to be reduced to less than 0.25 μm (one standard deviation), compared with two to three times that on current products. This implies the need for greater accuracy in tracking and seeking. While improvements in the mechanics and their actuators can be anticipated, the use of digital signal processing and sector servo technology would seem essential. With a sector servo, the position information is interspersed on the data surfaces, rather than residing on a dedicated surface to which the motions of the other heads are slaved.

Head technology is often driven by advances in recording media. In fact, the new metal-particle tapes used in 8-millimeter and R-DAT formats drove the development of M-I-G heads. The coercivity of metal-particle tapes was too high to be handled by ferrite heads.

Magnetic recording media have advanced well beyond what was available a decade ago, namely, half-micrometer-long needles of gamma ferric oxide or sometimes chromium dioxide densely packed into a plastic binder. New tape media, ranging from tiny flakes of barium ferrite to metal particles to evaporated metal tape, have all made their appearance.

A material world

The new materials have higher energy products for the magnetic recording media than untreated gamma ferric oxide. (The energy product is defined in approximate terms as the remanence, or amount of residual magnetization left on the tape, multiplied by coercivity, or its ability to resist demagnetization.) Untreated gamma ferric oxide has an energy product around 4 kilojoules per cubic meter (0.15 tesla × 28 kA/m). Treating the surface of the particles with cobalt can more than double coercivity: today's Super-VHS tapes boast an energy product of more than 10 kJ/m^3. The energy product of metal-particle tapes, at 30 kJ/m^3, is almost an order of magnitude more than that of tapes common a decade earlier.

Metal-particle tapes, which use alloys including iron and cobalt, have not only a much higher remanence, 0.25 T, but also high coercivity, 120 kA/m. They not only offer larger signals at the head, but also a better ratio of signal to media noise. The higher energy product of a metallic particle means it can be much smaller than an oxide particle. The lower limit on size is determined by the superparamagnetic limit, the point at which the individual particle's magnetic energy becomes comparable to random thermal energy that can spontaneously reverse its magnetization. Because the number of particles per unit volume determines the granularity, or the signal-to-noise ratio of the recording, smaller particles give lower levels of media noise, as well as allowing fabrication of smoother media, which permit closer contact with the head. (To get the highest resolution, a very small spacing between the head and the medium is essential.)

The chemical stability of metal particles over the long term has always been a concern, especially for keeping archival records. Therefore iron alloy particles are made with certain nonmagnetic components and are treated to chemically passivate and protect their surfaces. Unfortunately, the improved chemical and tribological properties mean that the potentially high remanence gain in using metal particles is not fully achieved.

The highest-energy media are formed with a continuous metal film rather than from particles. At best, particulate media are composed of 30–50 percent particles, the rest being the nonmagnetic plastic binder. The remanence of a metal film is potentially two to three times that of its particulate cousin. But, again, much of this advantage is lost in practice because the cobalt-nickel alloy films typically used must themselves contain goodly amounts of nonmagnetic components, including oxygen, to ensure chemical stability, improve durability, and diminish noise. As a result, the energy product of Hi-Band 8 metal-evaporated tape is only slightly above that of metal-particle tape. However, metal-evaporated tape does have one highly unusual feature. It is produced by oblique evaporation, which gives some out-of-plane anisotropy, often very apparent as a tilted columnar microstructure [Fig. 2]. While this leads to the peculiar property that the tape plays well only in the forward direction, it seems to be important in producing more output at the shorter recorded wavelengths required to reproduce high frequencies. The Hi-Band 8 format, with its improved picture resolution, records wavelengths of less than a half micrometer, equal to the wavelength of visible light.

The Hi-Band 8 metal-evaporated (ME) tape is an example of the thin-film media that have been widely used on rigid disks for some time. These are sputtered or plated on and then coated with hard carbon to improve durability during starting and stopping, when the head slides on the disk surface. But the development of metal-film tapes has been more difficult. Evaporation is the preferred approach, but this still poses major manufacturing challenges such as keeping the plastic tape substrate cool enough

to avoid damage, and controlling stress to prevent the tape from rolling itself up into a tube. Today's Hi-Band ■ metal-film tapes now offered by several manufacturers appear to have overcome these problems. Durability has always been a key issue since the tape surface is in direct contact with the scanning head and in ■ VCR is expected to withstand up to one hour of still framing. The surface topography is carefully controlled and ■ very thin surface layer is applied to protect the medium and to improve its resistance to wear.

Densities rise

In signal processing, the other major technology involved with magnetic recording along with heads and media, a sharp dichotomy exists in code design and detection between rigid-disk drives and tape recorders. But the appearance in both systems of ■ new signal-processing technique—partial-response, maximum-likelihood, or PRML—suggests the gap between the technologies may narrow. In PRML, the separation between magnetic transitions where regions of opposite magnetization meet is comparable to the length of the bit cell.

In rigid disks, every effort has been made to design the code to keep recorded transitions apart; in tape, standard transitions are often very close. A minimum of 1.5 bits between transitions is used for 2,7 code, the popular run-length-limited data code used in many rigid-disk drives, while transition separations as low as 0.44 bit are found in IBM's 3480 high-end tape drive. (Run-length-limited codes limit the minimum and maximum separation between magnetic transitions.)

The reasons are both historical and practical. Rigid-disk drives write at higher data rates, making it harder to handle closely spaced transitions in write current. The 3480 tape drive uses magnetoresistive playback heads, and widely spaced transitions that give large signal peaks are to be avoided since they can exceed the range over which the head produces a linear output. On tape, also, because of its relative thickness, widely separated transitions prove more difficult to overwrite completely.

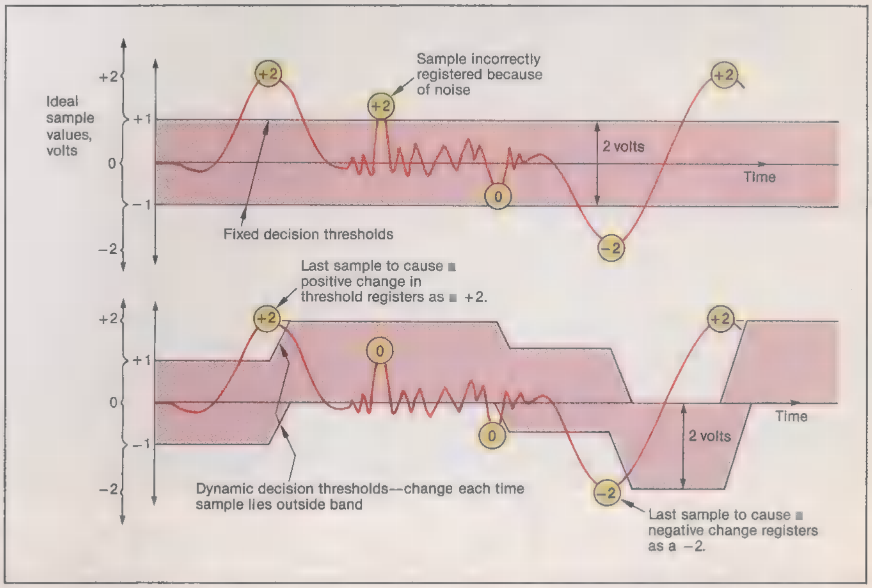
There is some evidence that differences between tape and disk-drive signal processing are getting smaller. PRML, which records transitions about 1 bit apart, is now to be found in both technologies. Also referred to as Class IV partial response with Viterbi detection, PRML incorporates new concepts of signal processing [Fig. 3]. The playback waveforms are first equalized or shaped such that even where complex patterns of transitions exist, a series of samples can be taken that are always limited to only three distinct levels (–2, 0, or +2 volts).

In maximum-likelihood detection, ■ signal can be sampled and its value interpreted relative to those of surrounding samples, rather than by measuring whether the signal has crossed a threshold with ■ fixed value. This enables otherwise ambiguous samples to be correctly interpreted, yielding a lower error rate or ■ higher bit-packing density.

PRML was first introduced in ■ product in 1984 by Ampex Corp., Redwood City, Calif., in its digital cassette recording system (DCRS) for very high data-rate instrumentation applications. Since then, PRML has become increasingly popular in experimental high-density work on both tapes and disks. Matsushita, Sony, and Philips Research Laboratories, Eindhoven, the Netherlands, have all used the technique in experimental digital video machines. IBM also used the technique in building its experimental 1.8-megabit-per-square-millimeter drive. Most significantly, however, the 5-1/4-in. disk drive in IBM's new RISC 6000 workstation employs PRML at 24 Mb/s, the first time the technique has been used in a commercial disk drive.

Signal processing has also allowed improvements in track density as well as the linear density achieved with PRML. The IBM 3380 family started at 32 tracks per millimeter, but the 3380E, the final member of this family, has about 80 tracks/mm—all with some basic mechanics in the head-disk assembly head, the enclosed unit that contains the disk, the drive heads, and the actuator, which moves the head radially.

The improvement is largely due to the use of a digital servo, which allows more exact control since algorithms adaptively estimate the physical attributes of the actuator inside the head-disk assembly—primarily its mass, force constant, and damping (resistance to motion). This enables the system to adapt automatically to variations in the voice coil motor's force constant (expressed ■■ newtons per ampere of current) and to any dc offsets in the electronics that may result from drift or manufacturing inconsistencies. More impressively, it can compensate for variations in the force constant from point to point as the actuator moves and also for variations in the gain of the position error signal that occur from the inside to the outside diameter of the disk. The position error signal derived from pre-recorded reference tracks indicates how far off track the head is.



[3] Partial-response, maximum-likelihood detection is a signal-processing technique used to achieve high storage density and prevent noise-induced errors. Partial-response waveform shaping (not shown) lets very high linear densities be achieved because it allows carefully controlled interference between adjacent bits, which would otherwise have to be well separated. Ideally, waveform samples take only three nominal values: –2, 0 and +2 volts. Maximum-likelihood detection, a digital-processing technique, is then applied to provide more margin against errors. The technique can be contrasted with conventional threshold detection (shown above). In this example, noise represented by a jagged line has pushed the marked sample outside the fixed yellow band, where it would have registered correctly as ■ 0. By contrast, in the maximum-likelihood algorithm (below) the yellow band is the same 2-V width, but its level is set dynamically. A sample that falls outside the band causes the level of the band to change. The last sample above the band registers as +2, while the last one below becomes a –2. All other samples are 0s. The algorithm is applied separately to odd- and even-number samples, though only one type of sample is shown. With partial response, ■ +2 cannot be followed by another +2 until an intervening –2 has occurred, a constraint in the sequence of samples that enables the algorithm to provide extra noise margin. Once the nominal values have been identified, the original binary data sequence can be easily deduced.

Digital magnetic, optical, and semiconductor storage

	Capacity, gigabytes per unit[1]	Density: Linear, bits per millimeter	Density: Track, tracks per millimeter	Density: Area, kilobits per square millimeter	Density: Stacking, surfaces per millimeter	Density: Volume, kilobits per cubic millimeter[2]	Data rate, megabits per second[3]	Time to data, seconds[4]
Magnetic rigid disks								
IBM 3390 (1989)—mainframe type	3.8	1100	88	96	0.08	8	34	0.02
Seagate Elite (1989)—5.25-in. type	1.2	1320	74	100	0.3	30	24	0.018
IBM demonstration (1989)	n.a.	6200	290	1800	n.a.	n.a.	28	n.a.
Magnetic digital tapes								
IBM 3480 (1984)	0.2	900	1.5	1.3	40	52	24	15
QIC 525 (1989)	0.525	800	5	4	120	480	2.0	40
Exabyte 8mm (1987)	2.3	2125	32	60	80	4800	1.9	100
R-DAT (1987)	1.3	2400	74	180	80	14 400	1.5	15
Matsushita digital VCR demo (1989)	36	2800	150	420	100	42 000	27	~120
Optical discs								
CD (1981)	0.64	1600	600	1000	0.5	500	1.5	0.6
Sony magneto-optical (1989)	0.64	950	740	700	0.4	280	0.7	0.1
Semiconductor								
4M-bit dynamic RAM (1989)	0.5	n.a.	n.a.	1200	n.a.	n.a.	12	80 ns

1 A unit is a head-disk assembly or tape cassette or optical disc
2 Off line for tapes and optical discs
3 Per head, except for the 18-head IBM 3480 and the digital VCR demo, which has two simultaneously active heads
4 Latency plus average access time for random seeks

n.a.–not applicable

These advances continue to push back the limits of a technology that Vladimir Poulsen, a Danish inventor, initiated around the turn of the century by conducting recording experiments on a steel piano wire. However, the criticism that magnetic recording is a mature technology in danger of stagnation apparently serves only to inspire new advances. There do not appear to be any physical limits to prevent stretching densities to many megabits per square millimeter or data rates to many hundreds of megabits per second. Current devices typically operate in the 20–200-kb/mm² and 10–100-Mb/s ranges.

The highest data rates are typically achieved on rotary-head machines, where as long ago as 1984 the Ampex DCRS was routinely recording at 117 Mb/s. Both Sony Corp. and Hitachi Ltd. have demonstrated data rates around 150 Mb/s in prototype digital high-definition television recorders, which used eight heads for a gross data rate exceeding 1 Gb/s. And as part of the U.S. Government's Magnetic Digital, Advanced Rotary Technology program, Eastman Kodak Co.'s Datatape Division, Pasadena, Calif., and GE Aerospace, Camden, N.J., are competing to achieve 300 Mb/s per head.

The most dramatic improvements have been in terms of capacity. The original Seagate 5-1/4-in. drive, introduced in 1980, boasted all of 5 megabytes. The latest offering from Seagate tucks 1.5 gigabytes into the same form factor. This is due not only to higher areal density (bits per unit of area), but also to the ability to pack many disks into a small package, or form factor. Consequently, capacity quadruples every three years, the same rate at which the much-touted dynamic random-access memory capacities are increasing.

Types of tape

It is unrealistic to suppose that storage systems involving mechanical motion will not eventually be displaced. Still, it is hard to imagine that happening within the next 25 years. This is especially true of magnetic tape that even now offers 420 kb/mm² on 10-μm-thick basefilm tape in Matsushita's experimental consumer digital VCR. Similar results have been reported by Ampex on a 4-μm-thick polyaramid tape from Toray Industries, Shigaken, Japan. Matsushita has claimed densities of 1 Mb/mm² using a vertically oriented metal-evaporated tape. The range of volumetric densities implied by these experiments is a remarkable 40–250 megabits per cubic millimeter. These high volumetric densities in tape systems are being called for by the need to back up, archive, or distribute increasingly large quantities of data in personal computers, workstations, and mainframes.

The demand for higher-quality audio and video and, in particular, for copying flawlessly through several generations of editing and distribution is driving this traditionally analog format into the digital world. R-DATs (digital-audio tape recorders with comparable quality to the compact disc) have been around for several years in the Far East, but with limited market success. Professional video recording for broadcast television is now often done using the D2 digital video format. While these D2 cassettes, at 37 by 20 by 2.5 centimeters, might seem large compared with the familiar VHS cassettes, a single D2 cassette can hold 200 gigabytes of data. Several manufacturers have demonstrated digital home VCRs that combine image compression and very high-density recording to achieve adequate playing time. There seems little doubt that digital home VCRs will become available over the next few years, although they will offer only limited improvements as long as they must operate within the existing television picture standards.

Magnetic recording is a dynamic industry. Annual sales now exceed $50 billion and can be expected to grow, not least because a number of universities in the United States, Europe, and Japan now boast a sizeable faculty and graduate student population dedicated to research in this field.

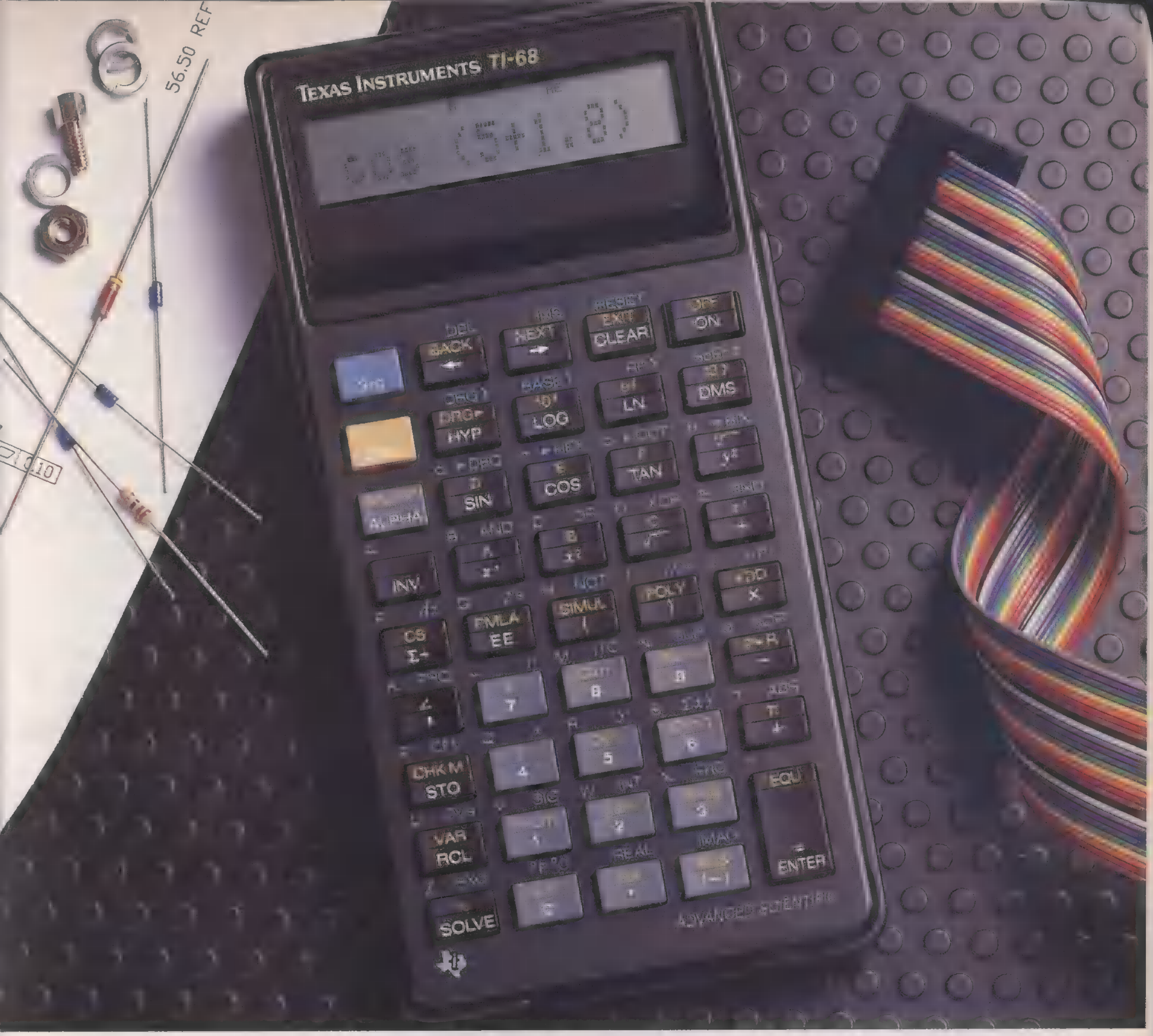
To probe further

A comprehensive overview of consumer, video, audio, computer tape, computer disk, and floppy-disk technology is provided by a three-volume set by Denis Mee and Eric Daniel, *Magnetic Recording,* McGraw-Hill, New York, 1987.

The September issue of *IEEE Transactions on Magnetics* contains papers from the annual IEEE Intermag conference. This year's conference was to be held in Brighton, England, on April 17–20. Four papers from this year's conference will report on IBM's gigabit-per-square-inch demonstration.

About the author

Roger W. Wood (A) is manager for advanced recording and data detection at the IBM Magnetic Recording Institute, San Jose, Calif. From 1979 to 1986, he was manager of the recording technology department with Ampex Corp., Redwood City, Calif., which manufactures tape recorders, tapes, and television-studio equipment. From 1972 to 1975, he researched microwave-relay systems for the British Post Office (now British Telecom). He received a bachelor's degree in electrical engineering from University College, London, and went on to earn a doctorate from the University of British Columbia, Vancouver, where he first specialized in magnetic recording.



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Metropolitan-area networks

Supplying more bandwidth than a LAN, a new networking scheme serves as a regional conduit for voice, video, and data services

In many U.S. cities and the regions surrounding them, businessmen and others have been finding local- and wide-area networks (LANs and WANs) less than adequate to their needs. LANs are too small or specialized for some applications, while Telenet, Tymnet, and other WANs are overkill for a modest community of users within a 50-kilometer diameter. In the last five years, metropolitan-area networks (MANs) have emerged or reached the experimental stage.

MANs were originally oriented toward data, but now often carry voice and video traffic as well. They support two-way communication over a shared medium, such as an optical-fiber cable, and may offer point-to-point high-speed circuits or packet-switched communication. They do not, however, have the huge traffic-handling capability of a switched exchange network, such as the present telephone system or the future broadband integrated-services digital network (BISDN), which will offer worldwide service. A cable television (CATV) network, which is essentially a broadcasting system, is not ordinarily classified as a MAN, but can be modified to support two-way MAN service.

In fact, MANs for business users are tending toward the first model, handling irregular bursts of interactive traffic in a cost-effective way. MANs for residential users are building out from the CATV model, in parallel with the public telephone network, to accommodate a highly asymmetric traffic mix and the public thirst for visual distribution services. Most of the capabilities of these nearer-term models may some day be available in all-services BISDN architectures.

Ultimately expected to transmit data at rates of 1 Mb/s or more within areas 50 km or so in diameter, MANs serve industry and education as well as business and the home. A good business example is the network built by Teleport Communications for the Port Authority of New York and New Jersey to link up bridges, tunnels, and other transit facilities in and around New York City. Eleven other MANs in the United States serve communities of a few dozen to nearly 400 000 customers [Tables 1 and 2].

MANs are still evolving in topology, data rates, and above all access protocols, to name but a few aspects. For residential MANs, an added challenge is the "last mile" problem—the medium linking homes to the network represents a major investment. Residential telephone cables and coaxial cables for television transmission are the media of choice, an estimated $300 billion worth of them being already installed in the United States alone. Optical fiber will follow only if the revenue from new services it promises to deliver (compressed still video images being one example) will justify the installation and maintenance cost.

How are MAN topologies derived? The star topology of the telephone system and the tree-and-branch configuration of the cable TV systems afford some clues. The star topology permits the transfer of data in the kilobit-per-second range between any two sites equipped with modems and at megabit-per-second rates between sites equipped with special 1.544-Mb/s circuits (2.048 Mb/s outside North America and Japan). The latter is costlier, typically requiring the equivalent of 24 voice circuits versus the modem's one voice circuit. In fact, with the existing twisted-pair local loops, even the much-discussed ISDN will only provide ISDN basic service at 144 kilobits per second.

Current CATV systems are not set up to transfer megabits per second between arbitrary sites. But their tree-and-branch topology is less to blame than their allocation of bandwidth. The two or three reverse channels available for transmission from the home are grossly outnumbered by the 50 or so forward channels on a typical cable system using subsplit allocation of channels, in which the reverse band occupies 5–30 megahertz and the forward band, 50–500 MHz. However, the bandwidth could be allocated using midsplit (5–116 and 168–400 MHz) or high-split (5–174 and 232–400 MHz) channels.

Although neither the star nor tree-and-branch configuration is wholly suited to carrying MAN traffic, each points toward practical adaptations. The star provides an individual physical circuit to each site. Tree-and-branch plus a suitable multiple-access-control (MAC) protocol lets packets of data (usually 1 to 2 kb long) share the medium while in transit to any destination site. The MAC protocol is required because it lays down the rules governing the allocation of the shared medium to different users. (Perhaps the best-known MAC protocol is Ethernet, which governs access to a coax-cable LAN.)

Double star

Designers of residential fiber MANs have typically favored a double-star configuration, in which a central head-end feeds to hub stations on the network, which, in turn, connect to groups

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Illinois Institute of Technology

Defining terms

Access protocol: a formal set of conventions governing the format and relative timing of messages that allow a user access to a network.
Broadband integrated-services digital network (BISDN): a network carrying data as well as digitized signals such as video typically at rates exceeding 64 kilobits per second.
Head-end: the source of all downstream, user-bound traffic on a star or tree-and-branch network.
Hub station: an intermediate distribution site.
Local loop: the link between the subscriber's equipment and the line-terminating equipment in the telephone exchange.
Node: the point at which a piece of user equipment connects to the network.
Packet: a group of data and control bits that is switched and transmitted as a unit.

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of residences [see illustration]. This configuration affords remote electronic switching such that the head-end processes users' requests and the hub station distributes the system's responses. Most business MANs to date, however, have a multiple-ring configuration, in which the primary, or center, ring encircles the heart of a business facility, and the rings of typically two to four such facilities are subsequently connected via bridges to a backbone ring. That configuration is more viable economically than the double star in densely populated areas due to the use of a shared medium.

To spell out some of the implications, the double-star topology can quickly allocate a physical circuit between two sites, but the transmission rate between the two, regardless of the overall switching capacity, C, of the central and hub switches, is limited to C/N, where N is the number of connections the switch may establish. In contrast, the application of a MAC protocol to a tree-and-branch topology (or for that matter almost any topology except switched star) allows the entire switching capacity, C, of the medium to be allocated to one connection for any length of time. Connections are established between arbitrary pairs of sites by allocating slices of time to each pair. The advantage is that zero or minimal capacity is used by stations not transmitting. A disadvantage where delay must be minimized is the need to packetize data before transmitting it.

Emerging MAN protocols

Protocols for MANs are still in development by such standards-making entities as the IEEE, the American National Standards Institute (ANSI), and the International Telegraph and Telephone Consultative Committee (CCITT).

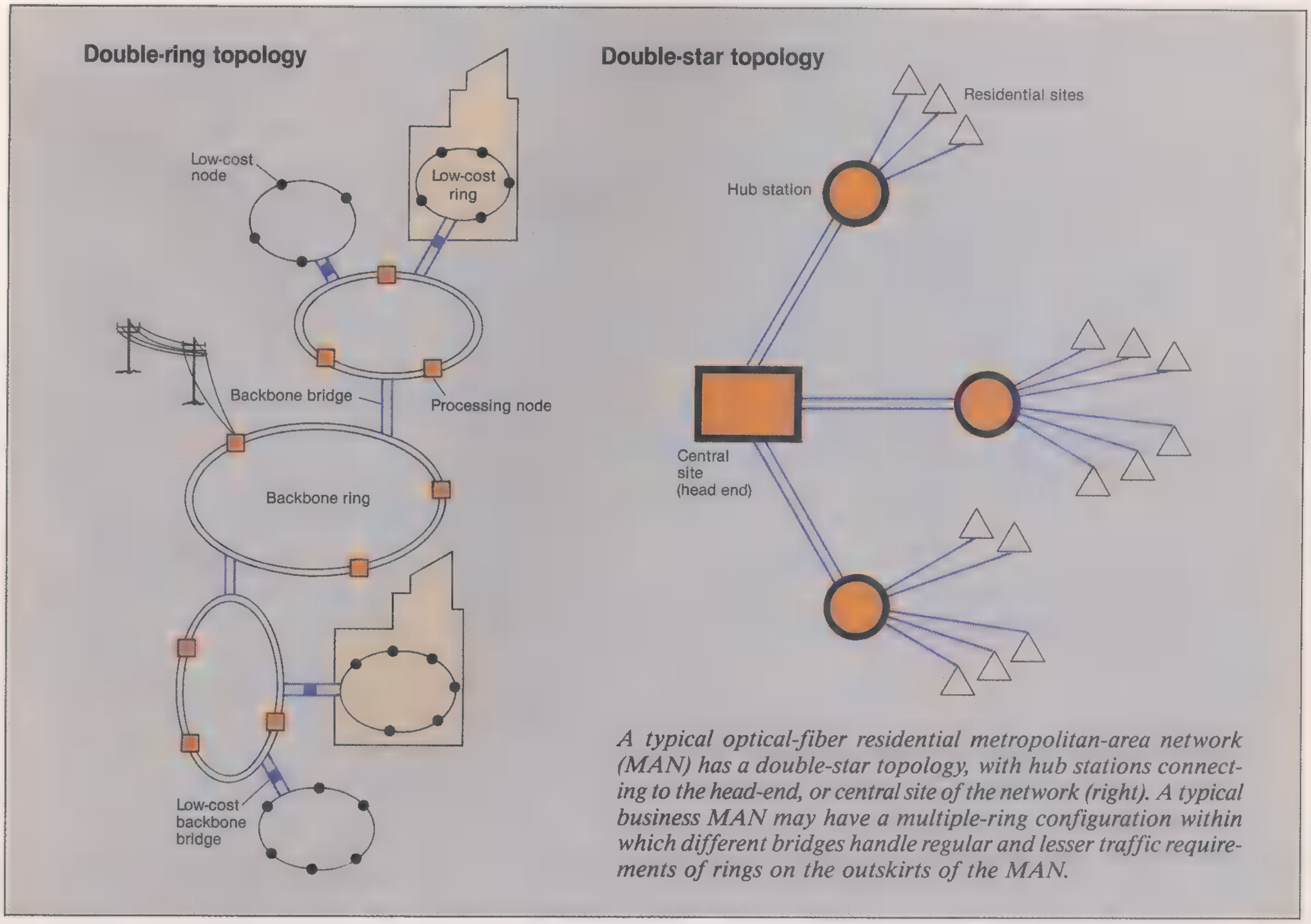
The IEEE's 802.6 Working Group on Metropolitan Area Networks has developed the distributed-queue dual-bus (DQDB) protocol, a generic name for a high-speed, shared-medium–access protocol consisting of pairs of buses funneling data in opposite directions. Still in draft form, it is expected to be quickly embraced by regional MAN providers and equipment vendors once the group votes to approve it later this year.

Queued packet-switching exchange (QPSX), the basis for DQDB, had already been developed by the University of Western Australia with Telecom Australia's support. Telecom Australia is establishing a DQDB MAN in Melbourne to demonstrate an operational QPSX MAN.

DQDB (QPSX) presuppose a network consisting of nodes attached to both lines of a double bus. Here empty frames—units of data, or packets—are continually transmitted from opposite ends on the double bus lines. When a station at a given node desires to transmit a packet, it determines which bus is carrying frames toward the destination station and then places a request bit in a frame traveling in the other direction (upstream) on the other bus; this request bit informs upstream stations on that bus that a node has entered the queue and requires an empty frame. The upstream stations monitor these requests and collectively allow one empty frame to pass by for each request, thus ensuring that the requesting station has access to an empty frame to transmit a frame downstream to the destination station.

DQDB is fair in that the requests by stations are honored in the order they arrive. DQDB is fault tolerant in that if the end station responsible for generating empty frames fails, the next station downstream assumes the responsibility; also, the bus can be configured as a ring so that if a break occurs, new end stations can start up on either side of the break and thus maintain full connection at full capacity for all stations. Data does not pass through network nodes, allowing nodes to be removed from the network without requiring network reconfiguration. And, possibly most impressive, DQDB provides close to 100 percent utilization of capacity.

The business market is watching two other protocols closely —the synchronous optical network (Sonet), being developed by



A typical optical-fiber residential metropolitan-area network (MAN) has a double-star topology, with hub stations connecting to the head-end, or central site of the network (right). A typical business MAN may have a multiple-ring configuration within which different bridges handle regular and lesser traffic requirements of rings on the outskirts of the MAN.

Table 1. Regional metropolitan-area network

MAN provider	Regional areas (date of first service)	# customers	Media	Type of services
Eastern Telelogic Corp., King of Prussia, Pa.	Philadelphia (7/89)	125	Fiber	Private lines, fractional T1[1], DS-1[1], DS-3[1], switched services
Intermedia Communications of Florida Inc., Tampa, Fla.	Orlando, Fla. (8/88); Tampa, Fla. (12/88); Miami, Fla. (5/90); St. Petersburg, Fla. (6/90); Jacksonville, Fla. (9/90)	75	Fiber	DS-1, DS-3
Metropolitan Fiber Systems Inc., Oakbrook Terrace, Ill.	Chicago (9/87); Philadelphia (9/88); Baltimore, Md. (4/89); Minneapolis, Minn. (7/89); San Francisco (8/89); Boston (10/89); Los Angeles (11/89); Houston, Texas (12/89); Pittsburgh (4/90); New York City (7/90); Dallas (9/90)	Not available	Fiber	Fractional T1, DS-1, DS-3
New England Digital Distribution Inc., Beverly, Mass.	Boston (12/82); Providence, R.I. (3/88); Manchester, N.H. (3/89); Hartford, Conn. (9/89)	100	Fiber, microwave	T1, DS-1, DS-3, local-area network (LAN) interconnection, customer-designed networks
Rogers Network Services, Toronto	Toronto; Kitchener-Waterloo, Ont.; Vancouver, B.C. (all 9/88)	75–90	Fiber, coaxial cable	T1, inter-LAN bridging, fractional T1, DS-1, DS-3, token ring or Ethernet LANs or channel extensions
Teleport Communications Group Inc., Staten Island, N.Y.	New York City (4/85); Boston (5/89); Houston, Texas, San Francisco, and Los Angeles (6/90); Chicago (late 1990–91)	N.Y.C. 70–75 Mass. 7–8	Fiber, coaxial cable	Private lines, fractional DS-1, DS-21, DS-3, LAN extender service, European standard (2.048 Mb/s), switched services

1 DS-1, DS-2, DS-3, fractional T1, and T1 are high-speed telecommunications services

Table 2. Residential metropolitan-area networks

MAN provider	CATV provider[1]	Site (date of first service)	# homes	Media	Types of services
Bell of Penn., Philadelphia	Helicon Cablevision Inc., Uniontown, Pa.	Perryopolis, Pa. (1/89)	65	Fiber	POTS[2], CATV[3] transport
Enterprise Videoway Ltée, Montreal	Videotron Ltée, Montreal	Montreal (9/89); Quebec, Que.[4], and Edmonton, Alta.[4] (both fall 1990)	15 000	Coaxial cable, fiber, microwave, satellite	CATV, IPPV[5], interactive television, data, videotex services, software downloading
GTE Service Co., Stamford, Conn.	Apollo Cable Vision Inc., San Luis Obispo, Calif.	Cerritos, Calif. (10/89)	250	Fiber, coaxial cable	Fiber: POTS, VOD[6], switched video Coax: CATV transport, IPPV, interactive video
KBLCOM Inc., Houston, Texas		San Antonio, Texas (7/82); Minneapolis, Minn. (6/84); Portland, Ore. (6/84)	392 000	Coaxial cable	San Antonio: CATV transport, IPPV T1, and lower speeds Portland: 9600-bit-per-second services
Southern Bell, Atlanta, Ga.	Heathrow Cable Ltd., Heathrow, Fla.	Heathrow, Fla. (11/88)	30	Fiber	POTS, CATV transport, switched video, advanced services
Warner Cable Communications Inc.,[7] Columbus, Ohio		Columbus, Ohio (1977); Cincinnati, Ohio (1979)	97 000 170 000	Coaxial cable	CATV, IPPV

1 Bell operating companies are not allowed to provide services directly to customers
2 POTS = plain old telephone service 3 CATV = cable television 4 Pre-implementation 5 IPPV = impulse pay per view 6 VOD = video on demand
7 Warner's first MANs, established in the late 1970s, have now been supplemented by 20 other systems operated throughout the United States

Bell Communications Research for eventual transmission rates of up to 13.22 gigabits per second and the fiber distributed-data interface (FDDI), a high-speed network standard developed by ANSI. Sonet provides both transport and multiplexing facilities for voice and broadband. FDDI specifies a 100-Mb/s optical-fiber ring and employs a token-ring algorithm, which constantly circulates a short series of bits (the token) round the net and, by insisting it accompany any message, ensures only one message is sent at a time. Unlike Sonet, which carries synchronous bit streams at the bit and byte level, FDDI supports a mix of stream and burst traffic as well as multipacket exchange.

At the same time, the CCITT is preparing BISDN standards for transmission rates ranging from 64 kb/s to 13.8 Gb/s, on the basis of its current ISDN standards. An important feature here is the asynchronous transfer mode (ATM), a flexible multiplexing format in which user information is organized in blocks with appended headers, each block and header forming a unit called a cell. Put in more general terms, ATM allows the switching of messages on a packet basis, rather than by smaller units of data, such as bits or bytes. Voice traffic traveling over an ATM switching network would require packetization, which presently is not under consideration. However, packet-oriented traffic services such as data and compressed video are admirably suited to an ATM MAN.

Connectivity to a variety of systems is a clear goal of MAN standard groups. Obviously, the success of any specific protocol depends in part on its ability to interface with other MANs. In the near future, MANs may concentrate on carrying non-real-time traffic while real-time (voice-related) traffic continues through current and improved plain old telephone service (POTS) facilities. The ultimate goal of MAN will be to carry integrated voice, data, and video traffic, the same goal as the phone system.

Who may provide MAN services? In the United States, which has been the site of most MAN development, telephone companies are forbidden by the 1984 Cable Act to carry video information, seen as an important part of any MAN, on the phone network within their own franchise areas. Nor are they allowed to do any programming. As a result, a telephone company seeking to carry such information must apply for the Federal Communications Commission's approval.

To probe further

"Optical fibers reach into home," by Paul W. Shumate Jr., writing in *IEEE Spectrum*, February 1989, pp. 43–47, examines the merits and potential impact of fiber optics to the home.

One of the earliest papers to address the subject is "A Metropolitan Area Network," by Daniel T. W. Sze, *IEEE Journal on Selected Areas in Communications*, November 1985, vol. SAC-3, No. 6, pp. 815–24.

A detailed overview of Sonet, ATM, and BISDN can be found in "Synchronous Optical Network and Broadband ISDN Protocols," by Anna Haćand Hasan B. Mutlu, *Computer*, November 1989, vol. 22, No. 11, pp. 26–34.

About the authors

Patricia A. Morreale (M) is completing a doctorate at Illinois Institute of Technology (IIT) in Chicago on MAN design and performance issues.

Graham M. Campbell (M) is professor of computer science at IIT. His current research interests center on the use of CATV facilities to transmit digital data. He has an extensive background in academia, industry, and government.

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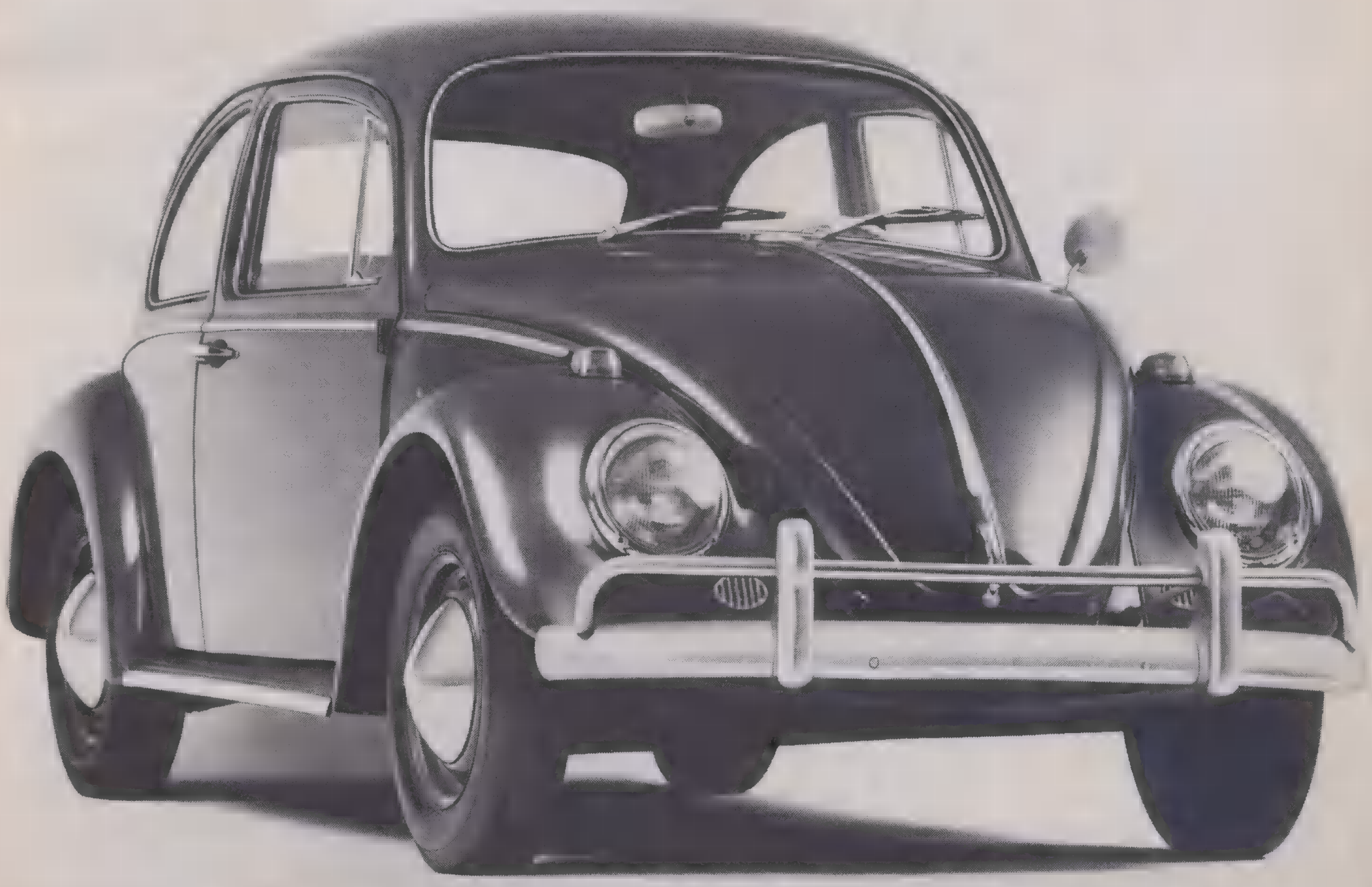

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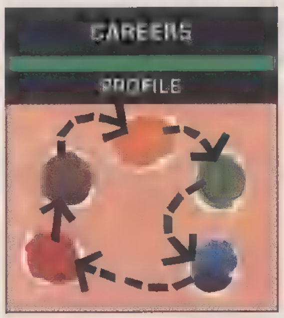
He builds tools for designers

Egyptian-born Amr Mohsen led the development of the 256K-bit CMOS DRAM and has formed two companies to help bring programming of custom microelectronics to the engineer's desktop



As a child in Cairo, Amr Mohsen's ambition was to win a Nobel prize for science. Like his heroes Galileo, Newton, and Einstein, he wanted to discover some law of nature that no one had before. Then, at age 15, tinkering with ■ home-built ham radio, he encountered electronics. "I found very quickly that while discovering physics laws is fun, applying scientific principles to engineering is even more fascinating," he told *IEEE Spectrum*. So he changed his major at Cairo University to electrical engineering, an agonizing decision at the time but one he says now was absolutely correct.

Since then, Mohsen has become ■ personification of Silicon Valley entrepreneurship. After leading the development of the first 256K-bit CMOS dynamic RAM at Intel Corp., he started a company that brought gate array programming to the engineer's desktop. Now he has founded another, which he says will allow engineers to create at their desks the printed-circuit boards that connect the chips of their design.

Mohsen was drawn to electrical engineering because its products can have "a profound impact on people's lives." But as his career developed, he narrowed his focus to the needs of electrical engineers. Tools for them, he said, will alter the world more than any consumer product, because "Many capabilities entrenched in microelectronics have yet to be unleashed, so the challenge is to provide the enabling technologies for engineers to use it in various applications."

No more ivory tower

Mohsen's education was ■ lengthy one. The son of an inspector in the Egyptian ministry of education, he graduated from a five-year electrical engineering program at Cairo University in 1968 and immediately undertook a two-year master's program at the American University in Cairo. His thesis advisor was ■ graduate of the California Institute of Technology in Pasadena and suggested that Mohsen should enroll there.

Mohsen went, studied under Carver Mead—best known for developing structured very large-scale IC design—and obtained ■ second MSEE in 1971 and a Ph.D. in 1973.

On his first job, with Bell Telephone Laboratories Inc. in Murray Hill, N.J., he continued the basic research in charge-coupled device ICs he had begun as Mead's graduate student. But after two years, he was ready to leave the ivory tower and explore an aspect of the United States that had fascinated him since his arrival: entrepreneurship.

"I wanted to develop ■ product that would make an impact on our industry," he recalled.

In 1975, Mohsen joined ■ few other Bell engineers to form ■ new company in Cupertino, Calif.—Mnemonics Corp. The group, funded by several Texas investors, developed smart memory systems using charge-coupled devices. But the venture ran into trouble: one founder was killed in a car accident, another fell ill, and the country as ■ whole went into a recession.

Those were dark days for Mohsen. His father died. His marriage of six years dissolved. He turned towards the Moslem religion to rebuild his faith in himself and the world. Mohsen vowed that he would, someday, start another company and succeed at it. But first, he realized, he needed more industrial and management experience. He took a job with Intel Corp. in Santa Clara, later moving to the company's technology development division in Aloha, Ore., where he became a corporate hero. In 1984, when the world was viewing the United States as a has-been in dynamic RAMs, he led ■ team that developed the first CMOS 256K-bit DRAM. It was introduced that year with much success.

Ready to act

Then Mohsen left Intel to start his own venture. He had become convinced that available programmable logic devices were not flexible enough to be useful to most engineers. Instead, he thought, engineers should be able to program true gate arrays on their desktops. In October of 1985, he formed Actel Corp., and by mid-1986 he had persuaded venture capitalists to bet $9 million that he could develop such a "desktop configurable channeled gate array" system. Mohsen determined that the best technology for user-programmable gate arrays was the antifuse, which is a deliberately easy-to-break-down capacitor. He intended to

Vital statistics

Name: Amr Mohsen
Date of birth: May 11, 1947 **Place of birth:** Cairo, Egypt
Height: 180 centimeters **Weight:** 73 kilograms
Family: wife (Mervat), four children (Raania, Happy, Waleed, Shereen)
Education: BSEE from Cairo University; MSEE from the American University in Cairo; MSEE and Ph.D. from the California Institute of Technology in Pasadena
Languages spoken: English, French, Arabic
Role models: Carver Mead, Robert Noyce, Gordon Moore
First job: testing electric motors at a factory in Vienna, Austria
Biggest surprise in career: "How much I enjoyed management"
Management credo: "Vision and trust"
Most recent books read: *Microcosm* by George Gilder; *Corporate Pathfinders* by Harold Leavitt
Favorite movie: *Casablanca*
Favorite food: French, Italian
Least favorite food: greasy burgers
Car: Mercedes 500 SEL
License plate: ACTEL
Favorite leisure activity: soccer
Patents: 17 issued, 8 pending
Memberships: IEEE Senior Member, American Physical Society, Association of Moslem Scientists and Engineers

Tekla S. Perry Senior Editor

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use antifuses to interconnect the wires in a gate-array chip, thereby making the chip field-programmable.

Researchers had been talking about dielectric-based antifuse devices for years; but no one had been able to manufacture them reliably in production quantities. Mohsen put a team of about 20 engineers to work on the problem. In December of 1986, after about six months of progress, the team ran into difficulties. "We realized that the way we had been measuring the device during the preceding months was wrong," Mohsen recalled, "and when measured properly, the resistance of the antifuse was a lot higher than we thought, and varied quite a bit. It would have been very easy to give up and say it can't be done, and so we don't have a company."

For three months the team worked constantly, staying at the lab nights and weekends, and the problem was solved (the solution is proprietary and a patent has been applied for). In July 1988, Actel introduced its first family of products, including chips with antifuses as unconducting links between logic gates, a development system to program the chips by applying voltage to the antifuses, and software for IBM-compatible PCs that handles automatic placement and routing as well as in-circuit diagnostics.

Making connections

The faith and persistence that carried Mohsen through Actel's toughest time is characteristic, people who know him say. *Spectrum* witnessed both attributes in action on a warm March Friday in Silicon Valley. Mohsen had a cast on his arm. A soccer fanatic, he normally plays in two games every weekend, but a too vigorous tackle had sidelined him. At lunch with a potential advisory board member, he quickly pushed the conversation away from small talk and onto a technical discussion of possible approaches to a new product he is developing, listening with warm attention but relentless in pursuing answers.

This friendly game of volleying thoughts is a favorite way of refining his ideas. Said Carver Mead, the Cal Tech professor who taught Mohsen in graduate school and whom Mohsen considers a mentor: "Amr is better at listening carefully than anybody I know. He doesn't pretend to know everything; he learns by asking a lot of questions." And John East, a former executive at Advanced Micro Devices Inc. of Sunnyvale, Calif., who is now Actel president and chief executive officer, said Mohsen rarely talks to anybody without extracting three or four ideas. East thinks this is one reason for Mohsen's success—he is not a victim of not-invented-here syndrome.

"It is easy when you come up with an idea to get married to it," Mohsen said. "But if you make yourself listen, you can easily turn a bad idea into a good one."

After that listening lunch, Mohsen spent several hours talking, presenting his plans to venture capitalists. He did not let their sometimes harsh comments distract him from the ideas he wanted to convey.

Said Mead: "Amr can put up with an incredible amount of abuse. He's more determined than anybody I know—and I know a lot of determined people. Getting Actel to work was incredible. In the beginning, nobody believed him. But by picking very good people and having a single-minded purposefulness, he got that product to be."

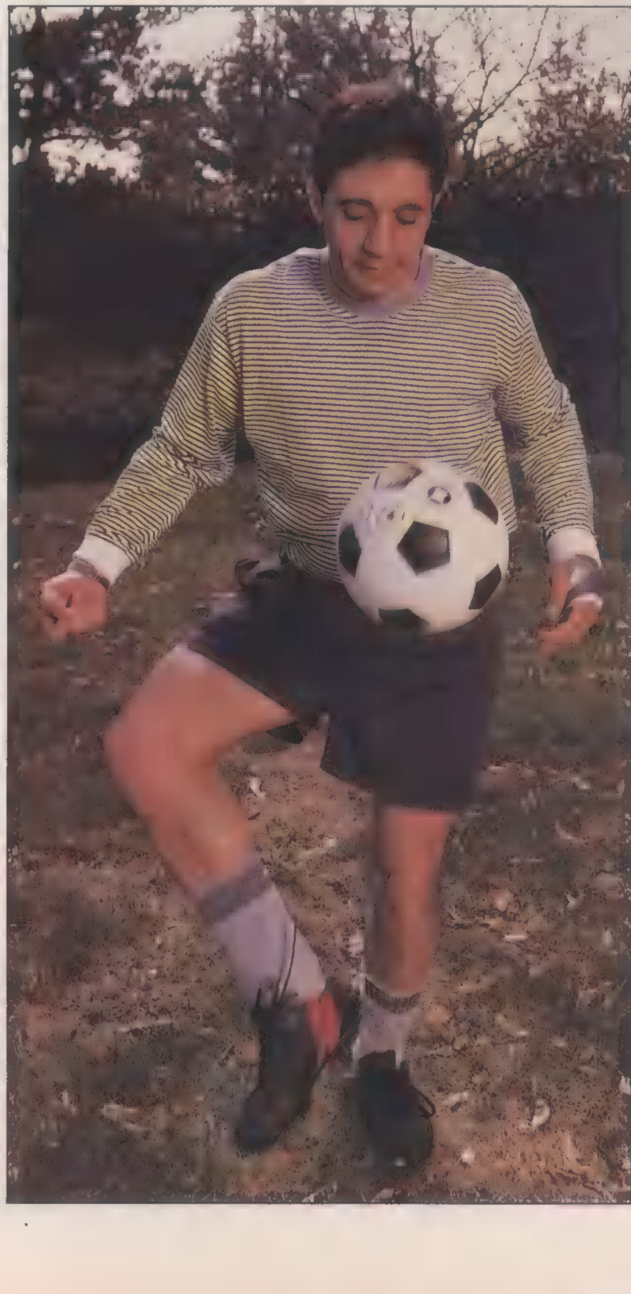
After installing East in his place, Mohsen resigned from Actel in June of 1989 but continued on the board of directors. Seeing Actel's products in use—his vision having become a reality—was thrilling beyond words, he said, but it made him itch to start over again, to "make another contribution."

Having talked to engineers who knew Actel's products, he identified a new market. Desktop programmable custom-logic chips were nice, he was told, but now what they really wanted were desktop programmability at the next level of integration—the interconnections between components.

Mohsen took a two-month vacation, traveling around the Middle East and Europe, then came back to the United States, set up a home office, and incorporated a new company: Connectus.

From that office, amid an eclectic library that includes engineering texts, books about entrepreneurs (from *The New Venturers* to *Trump: The Art of the Deal*), the latest management tomes, and a collection of Moslem tracts, Mohsen refined his idea for Connectus. He spent three months talking to engineers to better understand what they wanted. In December, sitting at his crowded desk, before a tapestry of Mecca, he wrote his business plan. With the New Year, Mohsen began approaching venture capitalists, potential employees, and anybody else he thought might have a good idea to contribute.

After the grilling by the venture capitalists, Mohsen met with the small group of engineers who will form the core of Connectus, reviewing the steps the company must take and, pending its funding, persuading them to squeeze even more design tasks into their nights and weekends, and meetings into their lunch hours, before leaving their current jobs. The slogan engraved around the license plate on Mohsen's car seems appropriate. "Follow me," it says, "the sky's the limit."

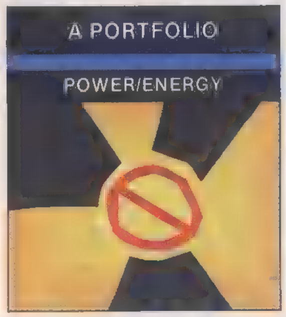


Cindy Charles

Entrepreneur Amr Mohsen, who has had a passion for soccer since he was three years old, usually plays every Saturday and Sunday afternoon. He sees the game as much like his work. "Soccer is results oriented," he said. "And success depends on a good balance of individual skills and team effort."

Shoreham in repose

A special pictorial of the dormant nuclear power station



The political tug-of-war over the Shoreham nuclear power station in Wading River, N.Y., is not over, but the odds seem heavily against the plant ever operating. Last summer the Long Island Lighting Co. (Lilco) removed the uranium fuel from the reactor and laid off one in three Shoreham employees—steps toward shutting the plant down—before even a kilowatt of commercial power had been delivered.

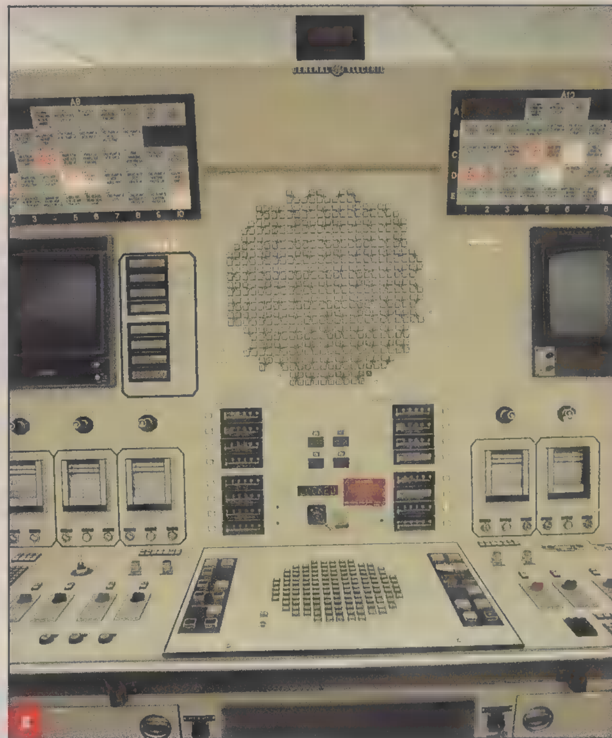
Until last spring, the Shoreham saga looked likely to stretch on forever, dooming the plant to an existence in limbo. With closure apparently at hand, *IEEE Spectrum* recently toured Shoreham with photographer Stephen Gill to capture samples of the prodigious technology within before it is closed to the world.

Shoreham, the first completed U.S. nuclear power plant to close before operating, is both symbol and proof of the travails of the U.S. nuclear power industry over the past two decades. Lilco announced the plant in 1966, but because of a succession of snags could not finish it until 1984. By then, opponents had turned both

(Continued on p. 48)

Karen Fitzgerald Associate Editor

For 10 years, these 69-kilovolt transmission lines, along with a set of 138-kV lines, have stood ready to transport up to 820 megawatts of power generated in the Shoreham plant's nuclear reactor (inside the cylindrical building) to communities throughout Long Island. The duct climbing the right side of the building exhausts air that has been filtered for radioactive iodine with 99 percent efficiency. Instead of using a tall stack, as some nuclear power plants do, Shoreham's design saves money by propelling the filtered air high into the atmosphere with booster fans.



(A) The central feature of Shoreham's control room is the panel for controlling reactor power, mainly through positioning of the control rods. These are interspersed among the fuel rods in the configuration evident on both horizontal and vertical panels. The operator selects a group of control rods for positioning by pushing the corresponding button on the horizontal layout. Colored lights on the vertical panel indicate which control rods have been selected and their current positions—either in or out of the fuel core. Two switches at lower right control motors that move the selected rods either in, to reduce power, or out, to increase it.

The rectangular groups of multicolored square indicators at the top, called annunciator panels, alert the operator to unsafe conditions. When a dark red light flashes, an alarm sounds, warning that a safety system or the reactor itself has been shut down. Other colors signify less serious warnings. Shoreham's control room was the first to tilt the indicators so that the operator can easily read them.

(B) Redundant red scram buttons, a pair on either side of the control rod drive panel, let the operator shut down the reactor manually. By rotating the button's outer collar, the operator arms the reactor logic for shutdown, and a white annunciator shines red when the logic has been enabled. The operator then pushes the button to begin the shutdown—an automatic sequence of control rod insertion.

(C) This set of gauges monitors the level of feedwater in the reactor. The operator sets the desired level by turning the black vertical thumbwheel to adjust the leftmost instrument's vertical gauge, which reads out in inches. Comparing the desired to the actual water level obtained from a sensor in the reactor, a control circuit generates a signal proportional to the water flow required to achieve the desired level. This signal reads out on the horizontal gauge as a percentage of the circuit's maximum output voltage (or the maximum water flow). The two instruments at right each control the speed of a turbine that pumps feedwater to the reactor. By pushing the small round buttons at lower left on each instrument, the operator can put the system under automatic feedback control, whereupon the signals from the left in-

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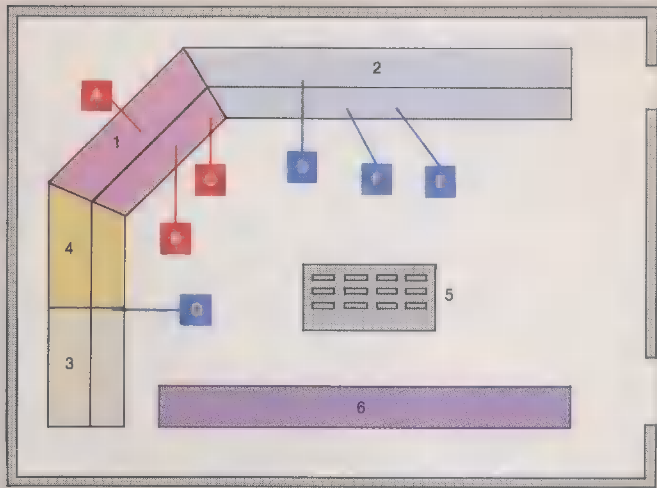
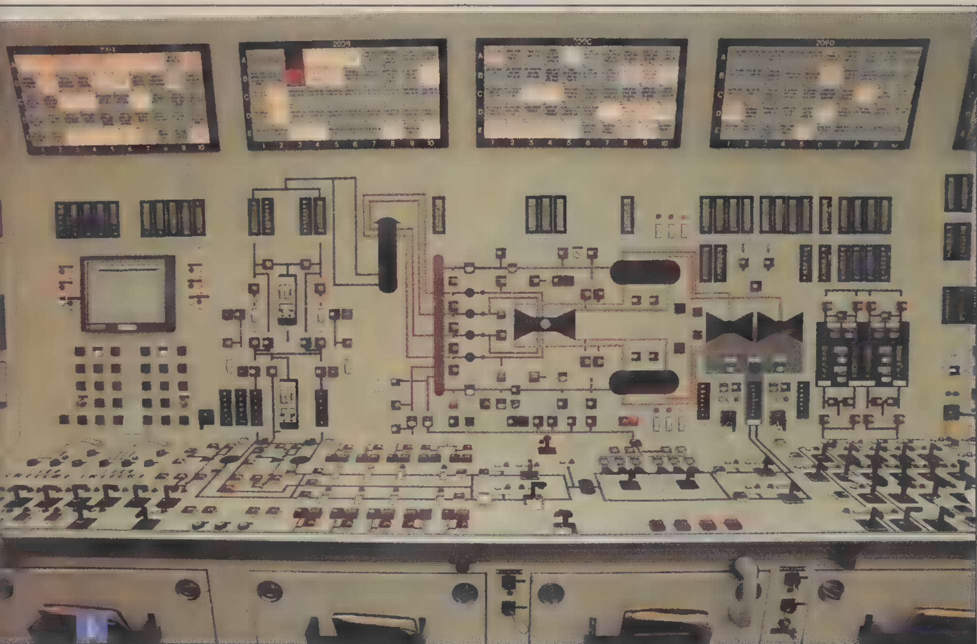
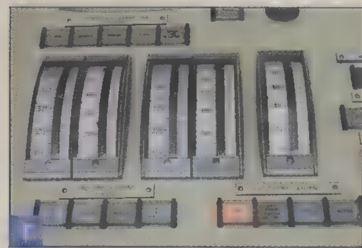
strument feed directly into the speed control circuits of the two turbines. During reactor startup, when water flow must be controlled manually, the operator pushes the button at right on each of the two rightmost instruments to light up the red indicator, and then pushes the black square buttons at the corner of each horizontal gauge to raise or lower turbine speed. This control scheme is employed throughout the control room, not only for water level, but also for temperature and pressure.

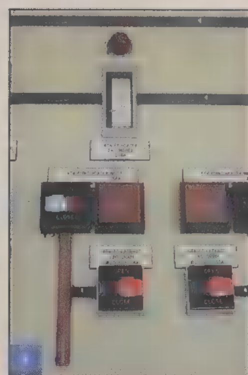


The focus of Shoreham's control room is ■ corner section of instrument panel (1) containing the reactor power controls and other nuclear instrumentation. The panel to the right (2) contains the instruments for operating the turbine generators, which produce electricity from the steam from Shoreham's boiling-water reactor. Also found in this section are the valves and pumps for the steam/water thermal cycle, the plant's electric system, and the diesel generators that must take over in the event of ■ primary power outage. Panel (3) contains the controls for emergency shutdown systems, including the core spray system and the low-pressure coolant injection systems. To the right (4) are controls for the high-pressure coolant injection system and auxiliary systems that manage both normal and emergency operations. Stations in the center (5) hold computer consoles that monitor and manage the operation of the plant. The remaining section (6) controls auxiliary ventilating and service water systems.

Photographs by Stephen Gill







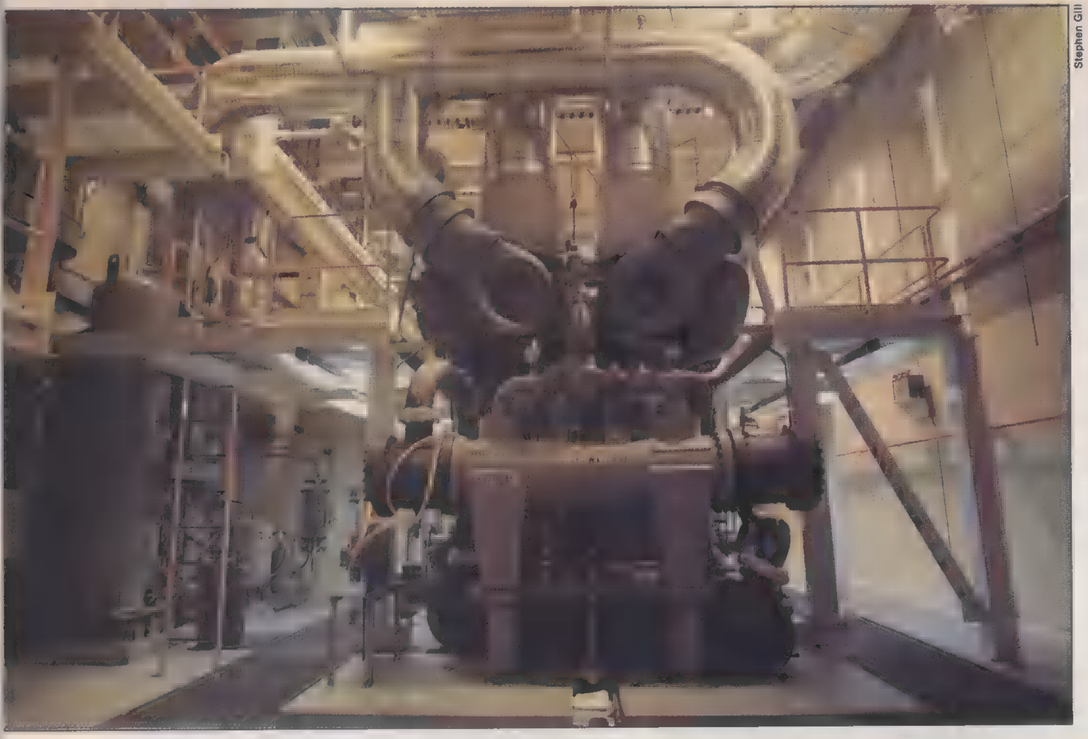
(D) This section of the control room operates the steam turbine generators, which take the steam that has been generated in the boiling-water reactor and convert it into electricity. Shoreham's control room designers, who had experience with fossil fuel plants, made extensive use of what is known as "mimicking," in which controls and indicators are inserted in ■ flow diagram (center) to give the operators a better feel for how specific actions would affect overall plant operation.

The following three photos highlight examples of generic controls that are applied for various uses throughout the control room:

(E) To operate the turbines, the reactor steam must reach a certain pressure level. The gauge at far left reads out the pressure set point—the minimum pressure level at which valves open to allow steam into the turbines—which the operator adjusts by pushing the square buttons below. The adjacent gauge on the same instrument reads out the actual reactor pressure from a Bourdon tube sensor, ■ bent metal tube that changes shape—and consequently electric output—in response to changes in pressure within it. The instrument at center is ■ redundant unit installed for reliability. The square pushbuttons at right adjust the warming of the turbine shell by controlling steam pressure within it, and the right-most vertical gauge gives ■ reading of the percentage of steam valve opening.

(F) After passing through the turbines, the steam generated in the reactor is condensed, purified and reheated, and then returned to the reactor as feedwater. The vertical gauge at top reads out the water level in the feedwater heater, and the red light above it turns on when the level gets too high, at which point the water could back up and impair turbine operation. The operator can either close the inlet valve to the heat exchanger by pushing the black "CLOSE" button at left or open the feedwater drain valve by pushing the "OPEN" button on the lower switch set. When the green light is on, the valve is fully closed; the red means it is fully open. By pushing the red "STOP" button, the operator can halt the closing or opening of the exchanger steam inlet valve to allow limited flow. In the flow diagram color scheme, the red line feeding into the valve switch signifies steam, while the black line running in line with the gauge represents feedwater.

(G) The steam line valves are very large and have to withstand high pressures and so are motor-operated. The operator actuates them by twisting a pistol grip control open or closed, as shown above for the main steam line drain valve. As is true for all valve controls, the green light means the valve is fully closed, while the red light means it is fully open. The blue light goes out when the valve motor is thermally overloaded, and the valve is rendered inoperable.



Stephen Gill

Lilco brought in three diesel generators made by Colt Industries Inc., including the one shown at left, to replace three made by Transamerica Delaval Inc. A crankshaft that broke in two during testing in 1983 indicated that the Transamerica generators were not designed to handle the required loads, and the event was used by critics to charge that design and construction of the plant were mismanaged. The generators were to supply power for coolant pumps and emergency shutdown systems in case of a primary power outage. The fiasco delayed the plant's completion by more than [redacted] year and added $619 million to its cost, according to the New York State Public Service Commission. Lilco also brought in four smaller diesel generators to fulfill requirements and later retrofitted the Transamerica generators to bring them up to specification. Consequently, the plant has more diesel generators than any other U.S. nuclear power plant.

As an added safety feature, a corium ring (right) was installed below the reactor pressure vessel in 1986, to direct the flow of molten fuel if it [redacted] to burn through the reactor vessel in a serious accident. The fuel would flow through the four holes in the cement ring down to the suppression pool where it would be cooled and solidified.

Long Island Lighting Co.

The uranium fuel bundle can barely be glimpsed through the water of the spent-fuel pool in the photograph below, taken shortly after the fuel was removed to the pool from the reactor last August, the first step in decommissioning the plant. The state may be able to sell the fuel for use in another nuclear power plant, but [redacted] seems likely to sit waiting while the fate of the plant is determined, just [redacted] it sat inside the reactor for the previous five years.

Stephen Gill

the county and state governments—and most of the Long Island populace—against the plant on the grounds that it was unsafe and that, in the event of a nuclear accident, the island could not be evacuated quickly enough.

Ironically, the end came in [redacted] unprecedented agreement between Lilco and New York State just [redacted] week before Lilco received a hard-fought full-power operating license from the Nuclear Regulatory Commission. In April of last year, Lilco agreed to sell the plant to the state for $1—plus [redacted] promise from the New York State Public Service Commission that utility rates on Long Island may be raised about 5 percent [redacted] year over the next decade. The agreement stipulated that the plant be shut down, but [redacted] controversy still rages over whether it should be dismantled, mothballed, or converted to using fossil fuel.

To prevent the plant from being dismantled—the state's intent—the Bush administration is challenging the legality of Shoreham's ownership by the State's Long Island Power Authority, which has never owned [redacted] nuclear plant or any other kind of power station. Shoreham opponents fear that if the plant is not dismantled, advocates may find some way to operate it. ◆

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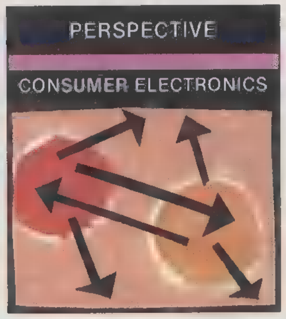
Friendly adversaries help U.S. companies

The two leading U.S. electronics trade associations, EIA and AEA, may not always see eye to eye, but they both provide aid and comfort to the industry



"There is a perception that the electronics industry is dying. I don't see it that way. On the contrary, I see it as our nation's most exciting, vibrant and dynamic industry, propelling us into the 21st century." So said Peter F. McCloskey, president of the Electronic Industries Association (EIA), Washington, D.C. He told *IEEE Spectrum*, however, that the biggest problems facing the electronics industry today are a lack of low-cost capital and poorly educated workers.

When the same question was asked of J. Richard Iverson, president of the American Electronics Association (AEA), Washington, D.C., and Santa Clara, Calif., he replied, "The biggest problem for the electronics industry is survival. We are seeing vital pieces of the U.S. electronics industry all but disappear with the demise of consumer electronics and the erosion of the once-dominant semiconductor industry position in DRAMs."

Though it is not uncommon for the two leading electronics trade associations in the United States to disagree, harmony is more usual between these powerful movers and shakers. Both lobby openly, independently or in unison, for causes they believe are vital to the electronics companies who are their members. But lobbying is just one of a host of activities in which they engage. Others include furthering science and engineering educational efforts and fostering ethical business standards.

Historically, what both groups have in common is their emergence from earlier organizations [see table]. The organization now known as EIA was founded in 1924—just four years after radio broadcasting began in the United States—by 17 radio manufacturers in Chicago that wanted to exchange experiences and organize a united front to combat various problems. These included the threat of patent suits, chaotic merchandising practices, the lack of technical standards, and upcoming legislative restraints.

The organization that became AEA was founded in 1943 by 25 electronics firms in Northern and Southern California that joined together to seek ways to reverse a War Production Board decision. That decision prohibited the awarding of contracts to the West Coast due to a perceived "acute labor shortage."

Today both organizations are primarily concerned with strengthening the competitiveness of the U.S. electronics industry.

Distinguishing features

EIA and AEA differ in several ways, most notably in their organizational setup. While EIA is structured nationally by product categories—telecommunications, consumer electronics, industrial electronics, components, and government electronics—AEA is organized regionally, with 21 councils in high technology concentrations distributed throughout the United States. EIA's members are for the most part large and medium-sized electronics companies, whereas AEA's members are large and small electronics firms.

Ronald K. Jurgen Senior Editor

Another distinction is that EIA is oriented more toward engineering, particularly in the area of standards. AEA does no standards work but concentrates on science and technology policy issues, pushing for such goals as National Science Foundation funding, construction of optical-fiber networks, supercomputer export controls, and the R&D tax credit. Much of AEA's concentration is on management programs, financial conferences, and industry surveys on salaries and benefits.

EIA has been more active in sponsoring trade shows, notably its highly successful Consumer Electronics Shows—in Las Vegas, Nev., in January and in Chicago in June. But AEA sponsors Wescon, the Western Electronics Show and Convention, and recently, it set up and ran a new trade show, called Systems/USA, in San Jose, Calif.

Both associations gather a myriad of industrial marketing and sales statistics, but the figures do not always agree. For example, EIA has estimated 1989 U.S. factory sales of electronic products at $256 billion, while AEA predicts $295.1 billion. The discrepancy is caused by two differences in how the totals are figured. First, EIA bases its estimates on information from its member companies and the U.S. Department of Commerce; AEA uses only Commerce data. Secondly, EIA includes in its figures sales of operating, but not application software; AEA includes both.

Lobbying is also done differently. McCloskey said that EIA has a number of policy councils (including the Government Procurement Relations Council, the Human Resources Council, the International Business Council, and the Tax Council) that guide the association's Legislative Affairs Council (LAC). LAC works through its own issue committees (defense, domestic, international, space, and tax) to carry out the legislative agenda determined by the EIA policy councils. Lobbying efforts are coordinated by the EIA staff and focus member companies' legislative resources on implementing the industry-set agenda. McCloskey said that this structure ensures the broadest possible industry input to policy development as membership in the EIA policy councils is open to, and drawn from, each of EIA's product-oriented groups.

AEA originates issue initiatives in its chief executive officer (CEO) public policy steering committees. According to Iverson, AEA Washington staff members run committees that do the lobbying. But unlike EIA, which often has staff members testify before Congress, AEA prefers to use CEOs of member companies for Congressional committee appearances.

One area in which EIA and AEA have recently shown considerably different approaches is high-definition television (HDTV). Last year, an AEA task force proposed that the Government and U.S. industry join together to develop and manufacture next-generation HDTV receivers. However, EIA's McCloskey subsequently told Congress that he did not believe any one technology should be singled out for manufacturing assistance. Rather, he said, the Government should concentrate on improving the

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EIA and AEA profiles

Organization	EIA	AEA
Date founded	1924	1943
Predecessors	Founded as the Radio Manufacturers Association (RMA), became the Radio-Television Manufacturers Association (RTMA) in 1950, the Radio-Electronics-Television Manufacturers Association (RETMA) in 1953, and the Electronic Industries Association (EIA) in 1957	Founded as the West Coast Electronic Manufacturing Association (WCEMA), became the Western Electronic Manufacturing Association in 1959, WEMA in 1969, and the American Electronics Association (AEA) in 1978
Primary goal	Enhance the competitiveness of the U.S. electronics producer	Foster a healthy business environment for the U.S. electronics industry, and engage in activities that strengthen its competitive position in marketplaces throughout the world
Number and type of members	Over 1000 U.S. manufacturing companies	2950 U.S. manufacturing, software, and telecommunications companies, and 500 industry service firms and universities
Membership dues	\$500 per year to \$26 000 per year, based on millions of dollars of sales	\$330 per year to \$50 000 per year, based on millions of dollars of sales
Overlap in members	Of top 50 companies who are members of EIA, 95 percent are also members of AEA	600 AEA members are EIA members
1989 income	\$30 million from member dues and trade shows	\$17 million mainly from member dues
1989 income allocation	\$3 million for engineering activities, \$2 million for Government relations, \$1.5 million for marketing statistics, rest for trade shows and administration	\$3 million for networking and councils, \$3 million for public policy, \$3 million for administration, \$8 million for various programs
Office locations	Washington, D.C. (new headquarters building under construction)	Headquarters offices in Washington, D.C., and Santa Clara, Calif., plus 17 other offices (16 in the United States and one in Japan), all rented
Staff size	182	138

general business climate for all technologies and should provide funding for precompetitive research.

Memorable feats

McCloskey told *Spectrum* that EIA's major accomplishments over the past 10 years include:

- Helping push through Congress the National Cooperative Research Act of 1984 (P.L. 98-462), which modified antitrust rules so that organizations like Sematech, the Austin, Texas–based semiconductor-manufacturing consortium, are legal.
- Helping defeat Internal Revenue Service Code 861-8, which made R&D more rewarding offshore than in the United States.
- Taking a leadership role in the successful effort to repeal Section 89 of the tax code, which mandated a highly costly and complex test series to prove nondiscrimination in employee benefit packages.
- Seeing that the Export Administration Act was modified to eliminate certain deterrents to exporting U.S. products and to help streamline the export process.
- Establishing a new EIA Design Automation Division that raised industry awareness of the economic and technical benefits of automating product design.
- Spearheading the implementation of programs for improving product quality.
- Influencing the U.S. Department of Defense on issues concerning procurement procedures and ethics.
- Creating the Telecommunications Industry Association, as an EIA-affiliated organization representing U.S. equipment manufacturers in that area.

Iverson cited these AEA accomplishments:

- Leading the legislative effort that resulted in cutbacks in capital gains taxes in 1978 and 1981.
- Assisting in the establishment of the Defense Industry Initiative on Business Ethics and Conduct.
- Helping to get the industry committed to alternative solvents to eliminate chlorofluorocarbons by 2000.
- Emphasizing the early development of superconductors and convincing the Presidential Science Advisor that the first conference on superconductivity be held.
- Elevating the debate on high-definition and advanced television technologies to a national level.
- Raising \$23 million for fellowships to support graduate scientists and engineers who agree to teach at universities for three years or more.

Both EIA and AEA are dedicated to helping solve the education dilemma in the United States, but each is taking a different tack. EIA has produced two films, *Inventing the future* and *Electronics. . .your bridge to tomorrow*, which are aimed at interesting high school students in mathematics and science so that they may consider technical careers. The association has also set up 41 week-long training programs in consumer electronics servicing for technicians and instructors in high schools, vocational schools, and community colleges.

EIA supports the Vocational Industrial Clubs of America, a group that holds an international "Olympics" competition for electronics technicians. EIA selects and sponsors the U.S. national winner and runs the international competition for consumer electronics product servicing.

In addition, through its Electronic Industries Foundation, EIA works closely with industry to train and place handicapped people in mainstream electronics work. So far, 6000 people have been trained and placed in jobs.

A major thrust of AEA's educational effort is its K-12 (kindergarten through grade 12) initiative, according to Iverson. K-12 encourages student activities that are aimed at producing a well-rounded, fully educated workforce, qualified for entry-level jobs in the electronics industry.

AEA also sponsors a Japan Research Fellowship Program, through which 10 engineering and computer science graduate students last year received language training and up to a year's working experience in Japanese company research laboratories. Another 11 will be sent to Japan this year, bringing the total to 52 participants since the program began in 1984.

Worldly interests

Although both EIA and AEA are chiefly concerned with U.S. activities, they also get involved in international meetings and programs. EIA, for example, will host an international standards meeting in Las Vegas, Nev., immediately following the 1991 International Winter Consumer Electronics Show in January. The meeting, with an expected 100 delegates from the United States, Europe, and Japan, will focus on the standardization of home automation and other information technology interfaces.

EIA's Consumer Electronics Group (CEG) serves as secretariat for Working Group 1 of the international standards-making committee, formed jointly by the International Standards Organization and the International Electrotechnical Commission (IEC). The CEG also sponsors the committee's Technical Advisory Committee on behalf of the United States. *(Continued on p. 49)*

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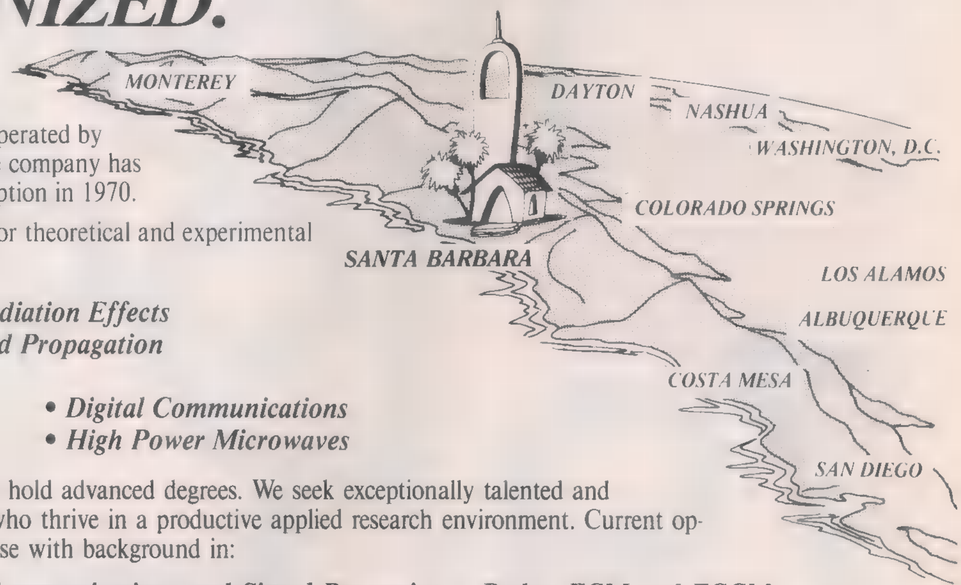

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Second International Conference on Economics and Artificial Intelligence (COMP); July 2-6; Paris, France; J-L. Le Moigne, GRASCE, University Aix Marseille III, 3 Ave. Robert Schuman, 13628 Aix en Provence, France.

Wescanex '90 on Telecommunication for Health Care: Telemetry, Teleradiology, and Telemedicine (IEEE); July 6-7; University of Calgary, Canada; Margaret-Anne Stroh, Conference Office, The University of Calgary, 2500 University Dr., N.W., Calgary, Alta. T2N 1N4, Canada; 403-289-7287.

Second International Conference on Factory 2001-Integrating Information and Material Flow (UKRI Section et al.); July 9-12; Churchill College, Cambridge, England; Louise Bousfield, Conference Organizer, The Institution of Electrical Engineers, Savoy Place, London WC2R OBL, England; (44+1) 240 1871.

IEEE Neural Networks Council-INNC-90-Paris (IEEE); July 9-13; Palais du Congrès, Pt. Maillot, Paris, France; Nina Thellier, NTC-19 rue de la Tour, 75116 Paris, France; (33+1) 45 25 65 65.

Power Engineering Society Summer Meeting (PE et al.); July 15-19; Marriott and Radisson Hotels, Minneapolis, Minn.; S. L. Larsen, Northern States Power Co., 414 Nicollet Mall, 8th floor, Minneapolis, Minn. 55401; 612-330-6149.

Third International Conference on Industrial and Engineering Applications of AI and Expert Systems (COMP); July 16-19; Omni Hotel, Charleston, S.C.; Moonis Ali, University of Tennessee, Space Institute, M/S-15, Tullahoma, Tenn. 37388; 615-455-0631.

Nonlinear Optics: Materials, Phenomena and Devices (IEEE/LEOS); July 16-20; Stouffer Waiohai Beach, Kauai, Hawaii; Glenda McBride, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 201-562-3896.

Fourth International Conference on Power Electronics and Variable-Speed Drives (IA et al.); July 17-20; Institute of Electrical Engineers, London, England; Jane Chopping, IEE Conference Department, Savoy Place, London WC2R OBL, England; (44+1) 240 1871, ext. 218.

Third International Conference on Vacuum Microelectronics (ED); July 22-25; Doubletree Hotel, Monterey, Calif.; Reedy Langevin, Courtesy Associates, 655 15th St., Suite 300, Washington, D.C. 20005; 202-347-5900.

LEOS Summer Topical Meetings—Broadband Analog Optoelectronics: Devices and Systems July 23-25; **Optical Multiple Access Networks;** July 25-27; **Integrated Optoelectronics;** July 30-Aug. 1; Monterey Sheraton, Monterey, Calif.; Glenda McBride, LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 201-562-3896.

Annual Conference of the Society of Instrument and Control Engineers of Japan (IE); July 24-26; Tokyo; Hiro Yamasaki, SICE President, 1-35-28-303 Hongo, Tokyo 113, Japan; (81+3) 814 4121.

AUGUST

LEOS Summer Topical Meetings—New Semiconductor Laser Devices and Applications; Aug. 1-3; Monterey Sheraton, Monterey, Calif.; Glenda McBride, LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 221-562-3896.

Second IEEE Power Electronics Society Workshop on Computers in Power Electronics (PEL); Aug. 6-7; Bucknell University, Lewisburg, Pa.; Thomas Sloane, Department of Electrical Engineering, Bucknell University, Lewisburg, Pa. 17837; 717-524-1269.

International Conference on Systems Engineering (AES); Aug. 9-11; B. A. Shenoi, Department of Electrical Engineering, Wright State University, Dayton, Ohio 45435; 513-873-3527.

33rd Midwest Symposium on Circuits and Systems (ASSP et al.); Aug. 12-14; Calgary Convention Centre, Calgary, Canada; Ronald H. Johnston, Department of Electrical Engineering, University of Calgary, 2500 University Dr., N.W., Calgary, Alta. T2N 1N4, Canada; 403-220-5003.

15th International Conference on Electric Contacts with 36th Holm Conference on Electrical Contacts (CHMT); Aug. 20-24; Le Grande Hotel, Montreal; Georgina Crane, IEEE, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 201-562-3863.

International Symposium on Electromagnetic Compatibility (EMC); Aug. 20-24; Washington Hilton Hotel, Washington, D.C.; Thomas W. Doeppner, 8323 Orange Court, Alexandria, Va. 22309; 703-780-3983.

International Conference on Solid State Devices and Materials (ED); Aug. 22-24; Hotel Sendai Plaza, Sendai, Japan; Kazuo Tsubouchi, Research Institute of Electrical Communications, Tohoku University, Sendai 980, Japan; (81+022) 227 6200, ext. 2836.

The East Coast Conference on Biomechanics (EMB); Aug. 26-28; New York College of Osteopathic Medicine, New York Institute of Technology, Old Westbury, N.Y.; H.S. Ranu, Department of Biomechanics, New York College of Osteopathic Medicine, New York Institute of Technology, Old Westbury, N.Y. 11568; 516-626-6926.

International Symposium on Signal Processing and Its Applications (Queensland); Aug. 27-30; Conrad International Hotel, Broadbeach, Australia; B. Boashash, CRISSSP, Department of Electrical Engineering, University of Queensland, St. Lucia, Australia 4067; (61+7) 377 3237.

Seventh International Conference on Electromagnetic Compatibility (UKRI Section); Aug. 28-31; University of York, England; Louise Bousfield, Conference Organizer, IEE Conference Services, Savoy Place, London WC2R OBL, England; (44+1) 240 1871.

SEPTEMBER

International Telecommunications Conference-

(Continued on p. 52E)

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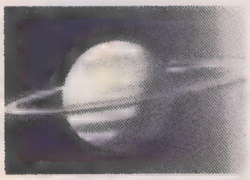

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IEEE Spectrum
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EOE M/F/H/V

CALENDAR

(Continued from p. 52C)

ITS '90 (COM); Sept. 3-6; Rio de Janeiro, Brazil; Jose Roberto Boisson de Marca, CETUC-PUC/Rio, Rua Marques de S. Vincente 225, 22453 Rio de Janeiro, RJ, Brazil; (55+21) 529 9450.

International Test Conference (COMP); Sept. 9-13; Sheraton Washington Hotel, Washington, D.C.; Doris Thomas, ITC, Box 264, Mount Freedom, N.J. 07970; 201-895-5260.

12th Semiconductor Laser Conference (IEEE/LEOS); Sept. 9-15; Congress Center, Davos, Switzerland; Hans Melchior, Institute for Quantum Electronics, Swiss Federal Institute of Technology, Ch-8093, Zurich, Switzerland; (41+1) 377 2101.

Managing Expert System Programs/Projects (COMP); Sept. 10-12; Washington, D.C.; IEEE Computer Society, Conference Services, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036; 202-371-0101.

Petroleum and Chemical Industry Technical Conference (IA); Sept. 10-12; Westin Galleria Hotel, Houston, Texas; J. R. Zahn, Reliance Electric Co., 340 N. Belt East, Suite 199, Houston, Texas 77060; 713-931-8100.

10th International Conference on Conduction and Breakdown in Dielectric Liquids (DEI); Sept. 10-14; Grenoble, France; R. Tobazeon, C.N.R.S.-L.E.M.D., 25 Ave. des Martyrs-166 X, 38042 Grenoble Cedex, France; (33+7) 688 1071.

Midcon '90 (Region 4 et al.); Sept. 11-13; Dallas Convention Center, Dallas; Electronic Conventions Management, 8110 Airport Blvd., Los Angeles, Calif. 90045; 213-772-2965.

International Professional Communication Conference (PC); Sept. 12-14; The Post House Hotel, Guildford, England; John B. Moffett, The Johns Hopkins University, Applied Physics Laboratory, Building 4, Room 379, Johns Hopkins Road, Laurel, Md. 20707; 301-953-5000, ext. 8260.

International Conference on Computer Design: VLSI in Computers and Processors-ICCD '90 (COMP); Sept. 16-19; Hyatt Regency Cambridge, Cambridge, Mass.; Edward M. Middlesworth, Hewlett-Packard Co., Building 250, Box 10350, Palo Alto, Calif. 94303; 415-857-5485.

16th European Conference on Optical Communication (LEOS); Sept. 16-20; International Congress Centre RAI, Amsterdam, the Netherlands; B. H. Berbeek, Philips Research Laboratories, Box 80.000, 5600JA Eindhoven, The Netherlands; (31+40) 743 240.

Bipolar Circuits and Technology Meeting (CAS et al.); Sept. 17-18; Marriott City Center Hotel, Minneapolis, Minn.; Jan Jopke, 6611 Countryside Dr., Eden Prairie, Minn. 55346; 612-934-5802.

Autotestcon '90 (AES et al.); Sept. 17-21; San Antonio Convention Center; San Antonio, Texas; Bob Hershey, SA-ALC/SCC, Kelly Air Force Base, San Antonio, Texas 78241; 512-925-7313.

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The Executive Officer is an IEEE employee and reports both to the officers of EDS and to the IEEE Staff Director, Technical Activities.

QUALIFICATIONS

A minimum of five years managerial experience and an understanding of finances is required. Familiarity with publications and conferences is desirable. Excellent interpersonal and communications skills are required. A technical degree is preferred.

RESPONSIBILITIES

Responsibilities include: financial analysis, managing technical meetings, coordination of publication and educational activities, establishment of procedures, and general execution of Society objectives and plans.

Respond to:
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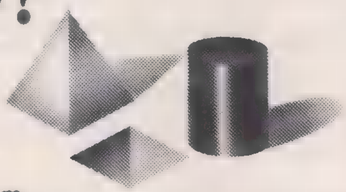
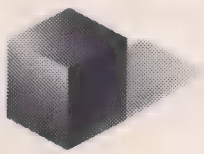
Who brings the best news to Silicon Valley in May?



When it comes to unparalleled opportunities in Process Development, Micron has the best news. From May 22–24, we'll tell you all about our new 6-inch Process Development lab where we're challenging the best to create submicron CMOS processes for 4-Megabit DRAMs. And because we're looking to be the leader in memory technology, you can expect substantial opportunities to advance every step of the way.



Micron does.

If you are interested in any of the following opportunities, be sure to see us during your visit to the Silicon Valley in May. Stop by our Open House at the San Francisco Airport Marriott Hotel on May 23rd, from 9am to 9pm (please check reader board for appropriate location), or call us as soon as possible at (208) 368-3180 to arrange for a confidential interview on May 22, 23, or 24.

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University of Minnesota Department of Computer Science

The University of Minnesota invites nominations and applications for the U S WEST Land Grant Chair in Telecommunications. Of particular interest are candidates with a strong research background appropriate to software technology for broadband public communications and computing environments.

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Interested persons should write or call Professor David Fox, Chair of the Search Committee for the U S WEST Chair, Department of Computer Science, University of Minnesota, 200 Union Street, Minneapolis, MN 55455. Tel 612-625-0726. Deadline for receipt of application has been extended to May 31, 1990.

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The NSF/IEEE CAEME Center is pleased to announce the availability of small grants (seed funds up to $5,000) to sponsor the development of educational software in electromagnetics with emphasis on undergraduate education. Areas of interest include:

- Visualization of basic laws of electromagnetics
- Interactive software packages for introductory electromagnetics; Maxwell's equation, vector operations, and wave propagation
- Time-domain and sinusoidal analysis of transmission lines
- Basic antenna theory and design
- Computer-based microwave laboratory

Proposals should consist of the following items:

- Description of the project including a statement of the precise objectives
- Explanation of procedure and schedule
- Hardware platform and software language
- Budget (one page)
- Courses suitable for implementing the developed software

Proposals should not exceed 10 pages, and the duration of funding may range from 6 to 12 months. A copy of the applicant's vita should also be included.

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- Matching funds/release time commitment by principal investigator's institution
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- Commitment by PI to write a chapter in one of CAEME's books and provide free copies of software and documentation

Successful institutions will be asked to sign letters of agreement specifying tasks, deliverables, and schedules. Submission deadline: May 30, 1990.

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MSEE or equivalent experience and at least 5 years in analog and digital communication systems development in an R&D environment required. **Box UL.**

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Lead the development of a variety of broadband systems, including advanced residential TV. Typically, these systems will include a mix of commercial equipment and experimental subsystems. Practical experience in engineering plus a good working knowledge of video systems essential. **Box CJ.**

Sr. Microwave Engineer

Contribute to the development of rf and microwave power subsystems for applications in GTE communication systems, military electronic systems, and novel microwave powered lighting systems. Emphasis will be on engineering studies and laboratory experiments leading to subsystem hardware development. This also involves microwave component characterization techniques including equivalent circuit modeling of power devices and microwave CAD analysis of devices and circuits. **Box RR.**

Research Scientist-Mobile Communication Systems

Research next generation cellular radio concepts for mobile and personal communications. Define high level systems architecture for small cell communication networks, radio engineering for in-building wireless systems, DSP hardware development and modem design for real time systems simulation and field tests for digital radio technology. **Box FD.**

Researcher-Speech Recognition and Coding

Contribute to our research effort focusing on the development of speech technology, with the primary emphasis on technology for future applications in telecommunications. Research areas include speech modeling, speech recognition algorithms and systems, compression and channel coding. PhD in EE or related field plus several years of experience required. **Box MB.**

Sr. Telecommunications Scientist-Switching Systems Research

Design and evaluate advanced switching systems and related technology for integrated (voice, data, video) intelligent communications networks. PhD in EE, Physics or related area, as well as 5-10 years' research in telecommunications or related area required. **Box MH.**

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You will bring a wide experience of video codec design approaches at all rates for various applications. You will undertake research in the area of novel video compression techniques. Knowledge of capabilities and limitations of present approaches is required to support the design and development of alternatives. The environment is to include NTSC and High Definition TV. **Box SW.**

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Technical and [illegible] Search

IC Design Engineer

Fermilab, a high energy physics laboratory recognized internationally for its engineering and physics activities, currently has an opening for an innovative engineer in IC design. We are responsible for state-of-the-art electronic designs in the area of high speed analog and digital circuits for use in experiments leading to [redacted] basic understanding of the structure of matter.

We are seeking an individual to use the latest CAE and CAD design tools for the design of semi-custom an custom integrated circuits as well as associated support circuits and tools. The job includes the development of specifications, design and simulation of VLSI chips, and testing of prototype devices for [redacted] in our unique experimental areas.

Requirements include a MSEE or equivalent training and a strong interest in IC design. Experience in bipolar and CMOS chip design is highly desirable.

Fermilab is located in the Fox River Valley west of Chicago, IL. We offer an excellent benefit and salary package. Please respond by mail with your resume and salary history to: **Mr. James L. Thompson, Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, IL 60510.** An Equal Opportunity Employer M/F.

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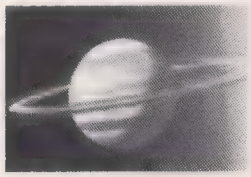

The Center for Space Microelectronic Technology at the Jet Propulsion Laboratory in Southern California has research positions available in development of analog computing devices, including analog memory devices, and electronic and optoelectronic hardware implementation of neural network architectures for space and defense applications.

SOLID STATE DEVICE PHYSICIST/ENGINEER

A Ph.D. in solid state physics or electrical engineering, with 2-4 years of research experience in applied materials science, amorphous semiconductors, thin films, and solid state microelectronic devices is essential. Knowledge of VLSI technology, digital/analog circuit design, and neural networks is desirable.

NEURAL NETWORK RESEARCH SCIENTIST/ENGINEER

A Ph.D. in electrical enginering, physics, or computer science, with 2-4 years of research experience in analog/digital design, VLSI technology (CAD tools, etc.), and semiconductor physics is required. Experience in neural network modeling and hardware implementation technology, analog signal processing techniques, and higher level computer languages is desirable.

Please submit resume to: Professional Staffing, Department T-61, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive 249/104, Pasadena, CA 91109. Equal Opportunity Employer.

JPL

Jet Propulsion Laboratory
California Institute of Technology

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REPUBLIC OF SINGAPORE

THE INSTITUTION

Ngee Ann Polytechnic (NP) is an internationally recognised tertiary institution in Singapore offering [redacted] the diploma level. It has a full-time student population of over 11,000 and [redacted] staff establishment of [redacted] 1,200. The medium of instruction is English. NP is committed [redacted] achieving its mission of academic excellence in all [redacted] courses.

Applications are invited for the following academic appointments:

1. Experts

Salary negotiable and will commensurate [redacted] qualifications [redacted] experience.

2. Principal Lecturers (S$73,260 - S$90,000 p.a. gross)

3. Senior Lecturers (S$53,160 - S$68,000 p.a. gross)

4. Lecturers (S$23,600 - S$62,000 p.a. gross)

REQUIREMENTS

- An interest in teaching
- Good verbal and written communication skills in English
- Professional qualifications and teaching experience [redacted] advantage
- Mastery of 2 or more of the fields listed under each department
- Personal integrity and commitment [redacted] the service

1. Experts

Highly qualified with not less than 10 years of relevant industrial and teaching experience.
Appointments [redacted] on **one-year** contract terms; may be extended.

2. Principal and Senior Lecturers

Highly qualified with good industrial or relevant experience. Lecturing experience an advantage.
Appointments are on **three-year** contract terms; renewable.

3. Lecturers

Minimum 2 years' relevant industrial experience preferred.
Professionals and post-graduate researchers with relevant qualifications and experience may also apply.
Appointments are on **three-year** contract terms; renewable.

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4. Robotics and Industrial Automation
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11. Industrial Electronics Design and Application
12. IC Design

(B) ELECTRICAL ENGINEERING DEPARTMENT

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APPLICATIONS

Applicants [redacted] invited [redacted] apply in writing, with copies of educational certificates and full particulars of qualifications, experience, current and expected salaries to: **HEAD/HUMAN RESOURCES, NGEE ANN POLYTECHNIC, [redacted] CLEMENTI ROAD, SINGAPORE 2159. (Fax: 4687326, Tel: 4666555).** Applications close on **31 May 1990. The application [redacted] be faxed first and followed by the original through the post.**

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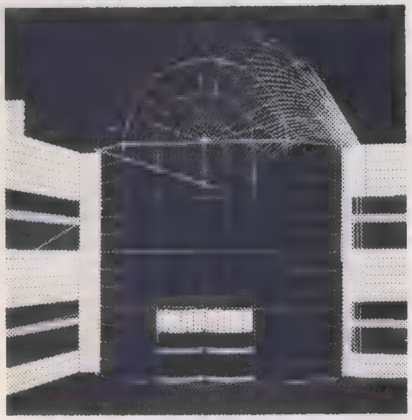

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Applicants must have completed a Ph.D. degree or must have an equivalent combination of education and experience. The position's starting salary is in the range of $29,657–$65,444 depending on qualifications and experience. Please send [redacted] Personal Qualifications Statement (SF-171) or resume plus transcripts or OPM Form 1170/17 to:

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VAC NO: NIST/DH-90-0349/JC
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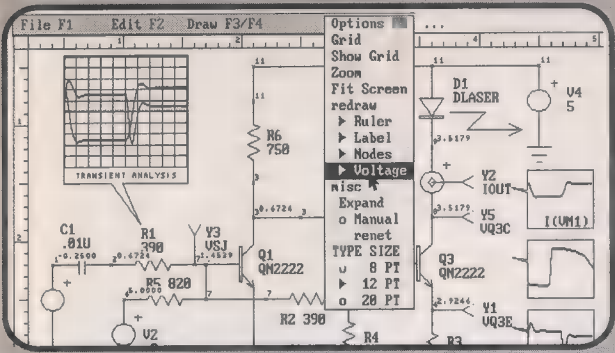

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Circle No. 5

THIRD CONFERENCE ON THE METHODS AND USES OF PRECISE TIME IN POWER SYSTEMS

September 25-26, 1990, Red Lion Inn, Spokane, Washington

ANNOUNCEMENT AND CALL FOR PAPERS

The third conference on the uses of precise time-keeping in the operation, analysis, and testing of power systems and power system components is sponsored by Department of Electrical Engineering, University of Idaho. Topics covered include:

- Available time services
- Global Positioning Satellites
- Fiber optic techniques for frequency dissemination
- Time code generator technology

Papers are invited in the areas of application of precise time and/or frequency to power systems. Possible areas are:

- Public timekeeping by utilities
- Event recorder synchronization
- Disturbance analysis using synchronization equipment
- Voltage phase angle measurement
- Advanced power system control
- Protective relay testing
- Fault location

Before July 1, 1990 Prospective authors should submit a 50 word abstract and a 300 to 500 word summary to Robert E. Wilson, Department of Electrical Engineering, University of Idaho, Moscow, Idaho 83843.

****Before August 15, 1990**** Authors must submit the final paper and figures appropriate for a 40 minute paper.

*****Registration & Information***** Conference registration is made with the Conferences and Enrichment Program, University of Idaho, Moscow, Idaho 83843; 208-885-6486. Registration fee: $150.

******Hotel Registration****** Guests should make their own hotel reservations with the Red Lion Inn, North 1100 Sullivan Road, Spokane, WA 99220, telephone 509-924-9000. Be sure to indicate "Time in Power Systems Conference".

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Circle No. 11

EIA and AEA

(Continued from p. 48)

EIA Engineering plays a major role within the (IEC) and its quality assessment system, the IECQ. EIA's Passive Parts committees, Fiber Optic committees, Semiconductor committees, and Consumer committees are active in developing specifications that will be used in the IECQ system.

As a result of EIA participation in the IEC's Advisory Committee on Electronics and Telecommunications, a special meeting was convened with representatives from EIAJ in Japan—EIA's Japanese counterpart, which is not affiliated in any way with EIA—and Cenelec, the European Committee for Electrotechnical Standardization in Brussels, Belgium, to determine appropriate ways in which existing and future surface-mounting standards can be moved into the IEC.

Among AEA's 1989 international activities was the sponsoring of a delegation headed by Iverson to Brussels and Geneva, Switzerland, for talks with European Community leaders. The trip underscored AEA's determination to inform its members of the implications and impact that the elimination of numerous internal European trade barriers will have on U.S. exports.

In 1985, AEA opened an office in Tokyo to support U.S. companies in lobbying the Japanese Government and in helping them do business in Japan.

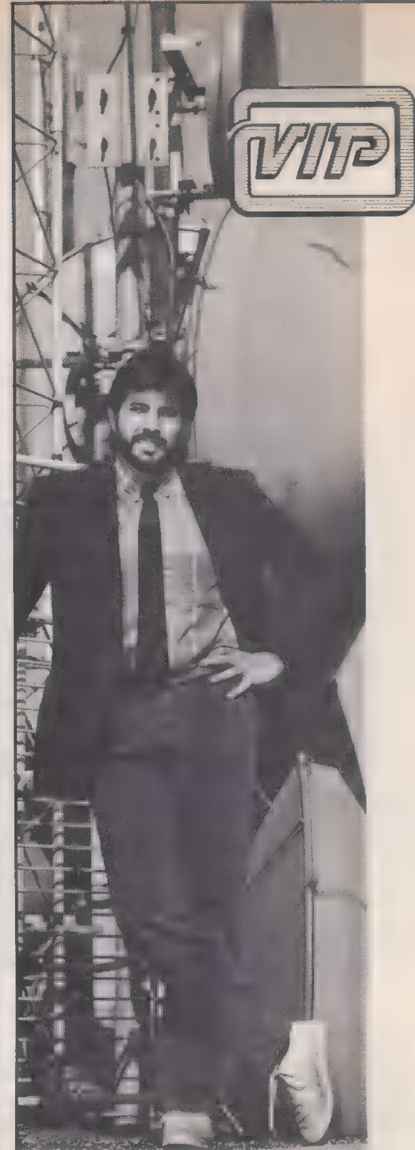
The AEA Industry Committee is an affiliate of AEA and serves as representative of the U.S. electronics industry in Japan. Last year, it became the first non-Japanese organization to receive Government approval to establish a pension trust fund for employees of U.S. electronics firms in Japan.

AEA has been working closely with U.S. negotiators in the Uruguay Round—a government-to-government panel considering questions of international trade—to ensure that U.S. electronics interests are recognized in the discussions, which include representatives from more than 100 countries. Last year AEA's delegation to Geneva stressed the need to resolve tariff and nontariff barriers on the export of U.S. electronic products before the Round's conclusion this year.

To probe further

Annual reports for 1989 are available from both EIA and AEA. For copies, contact the Electronic Industries Association, 2001 Pennsylvania Ave., N.W., Washington, D.C. 20006, 202-457-4900, and the American Electronics Association, 1225 Eye St., N.W., Suite 950, Washington, D.C. 20005, 202-682-9110.

EIA also publishes a catalog of EIA and Joint Electron Device Engineering Council standards and EIA engineering publications; copies are available from the above address. ◆



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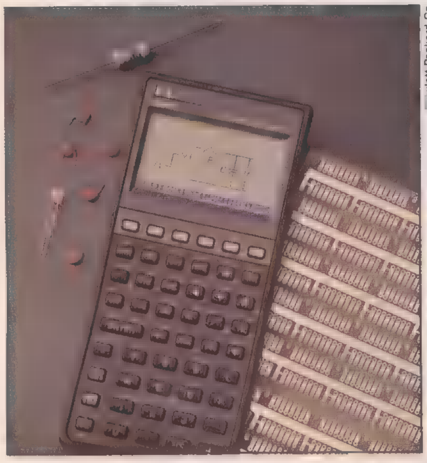
A calculator with common conversions

Engineers now have a calculator that not only displays equations and graphics, but also automatically converts different measurement units into a common unit, such as inches and centimeters into centimeters. With an optional cable interface and software, the 48SX scientific expandable calculator from Hewlett-Packard Co., Palo Alto, Calif., can also link up with IBM-compatible and Macintosh PCs.

The 48SX comes with a two-way infrared interface. Equations can be entered the way they are written instead of first being converted into computer language form. Equations, functions, bar charts, histograms, and other graphs are shown in an eight-line-by-22-character display.


Hewlett-Packard Co.

The optional PC-linkup is provided by a serial cable and data communications software on 3 1/2- and 5 1/4-inch disks. Another option is a library application card that provides more than 300 engineering and science equations.

The calculator is available now for $350. The PC interface and the library application card are each $99.95. *Contact: Inquiries Manager, Hewlett-Packard Co., 1000 N.E. Circle Blvd., Corvallis, Ore. 97330.*

Low-cost, high-level logic design

With a low-cost software package for multilevel logic synthesis, designers of gate arrays and standard cells can join designers of programmable-logic arrays and logic devices who have been using IBM-PC-compatible computers as their platforms.

Called Instant Logic, the package has synthesis programs—which create schematic diagrams and netlists, or circuit design descriptions of structural elements and their interconnections—and optimization programs—which analyze and improve existing schematics or netlists by minimizing circuit size or delay.

Logic design is speeded up because the software automatically translates a high-level description into a multilevel logic structure. It also creates schematic diagrams that can be viewed, printed, or transported to OrCAD or P-CAD schematic entry systems through an optional interface software.

Instant Logic's basic software has a generic library of over 100 combinational and flip-flop primitives. Popular application-specific IC databook libraries and schematic interfaces are scheduled to be added later this year.

The $495 package includes telephone support and upgrades. *Contact: Autodesign Inc., Box 12051, Research Triangle Park, Durham, N.C. 27709; 919-490-0482.*

Certifiable homework

Hitting the books at home to earn continuing education units (CEUs) could lead to job-related certification. Several study-at-home courses amassing CEUs are offered by Heath Co., a subsidiary of Groupe Bull, Paris, France. Among them are microprocessor applications, surface-mounting technology, artificial intelligence, data communications, and amateur radio. Optional video or audio tapes supplement course workbooks. A free catalog, "Homeworks by Heathkit," is available. *Contact: Heath Co., Department 350-048, Benton Harbor, Mich. 49022; 616-982-3991.*

Amadeus on a Mac

At last, hackers who aspire to be opera *cognoscenti* have a means to achieve their goal. The first of a series of recordings combining compact-disc audio and read-only memory (ROM) allows them to listen to an opera while studying its libretto on a Macintosh computer monitor.

The three-disc CD-ROM set, Mozart's "The Magic Flute," performed by the choir of the Zurich, Switzerland, opera house, is offered by Warner New Media, Burbank, Calif.

Data from the dual-storage CD system is loaded into the computer, and the CD system is then hooked up to the stereo system that will play the opera. Timed to the musical performance, the computer monitor displays such multiple-screen information as the English and German libretti, musical commentary, and narration.

The set is available now for $66. *Contact: Warner New Media, 3500 Olive Ave., Burbank, Calif. 91505; 818-955-9999.*

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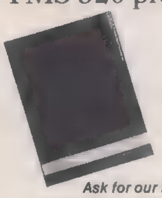
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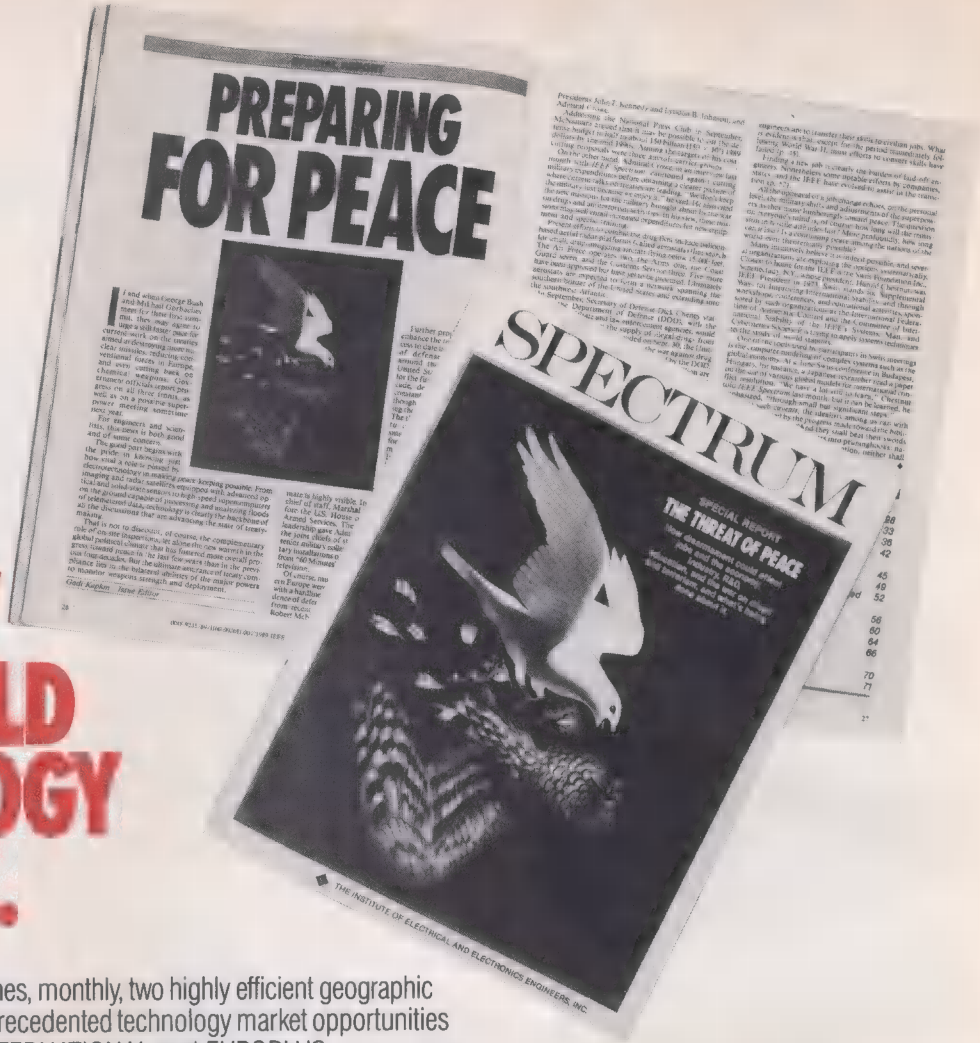

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Located at the Institute's headquarters in New York City, the IEEE Center for the History of Electrical Engineering produces historical books and articles, prepares exhibits, maintains the archives of the IEEE and its predecessor organizations, compiles guides to primary and secondary sources relating to electrical science and technology, and publishes a newsletter.

To enable the Center to expand its activities, the IEEE has established a Friends program. Contributions to the Friends Fund should be made payable to the "IEEE Foundation—Friends Fund," a not-for-profit organization that the Internal Revenue Service has ruled is eligible for tax-deductible donations.

To receive a complimentary copy of our newsletter, and to learn more about the Center's activities, CIRCLE #75 on the Reader Service Card.

NEURAL NETWORKS 1989
8 New Home Video Tutorials
presented by IEEE's Educational Activities Board in cooperation with the IEEE Neural Network Committee

- ADAPTIVE PATTERN RECOGNITION—Leon Cooper
- NEUROBIOLOGY REVIEW 1989—Walter Freeman
- ADAPTIVE SENSORY-MOTOR CONTROL—Stephen Grossberg
- NEURAL NETWORKS: ALGORITHMS AND MICROHARDWARE—John Hopfield
- VLSI TECHNOLOGY AND NEURAL NETWORK CHIPS—Lawrence Jackel
- OPTICAL NEUROCOMPUTERS 1989—Demetri Psaltis
- STARTING A HI-TECH COMPANY—Peter Wallace
- REINFORCEMENT LEARNING—Ronald Williams

For more information, call IEEE Educational Activities at 201-562-5499, or CIRCLE #80 on the Reader Service Card.

Home Video Tutorial
ESTIMATING ELECTRICAL LOADS FOR PLANNING ELECTRICAL DISTRIBUTION SYSTEMS
Developed and presented by Declan F. Klingenhagen, P.E., President of Klingenhagen Engineers, P.A., of Columbia, S.C.

When new buildings and facilities are required, an estimate of electrical loads is necessary to plan the electrical distribution system and determine the type and amount of service needed from the Power Company. This Home Video Tutorial covers the application of demand and diversity factors to estimate loads and shows how such factors can be used to help set up adequate-sized electrical distribution equipment for the least cost. The problems worked out in the tutorial use practical demand and diversity factors based upon experience.

For more information, call IEEE Educational Activities at 201-562-5499, or CIRCLE #[illegible] on the Reader Service Card.

IEEE CODE OF ETHICS

Engineers affect the quality of life for all people in our complex technological society. In the pursuit of their profession, therefore, it is vital that engineers conduct their work in an ethical manner that will merit them the confidence of colleagues, employers, clients, and the public. The IEEE Code of Ethics represents this standard of professional conduct for engineers.

IEEE-USA has printed the IEEE Code of Ethics as revised by the Board of Directors in November 1987. The Code is being made available on *parchment* suitable for framing (12 inches by 16 inches) from the IEEE Service Center (800-678-IEEE) at a cost of $5. Members are encouraged to use these parchment Code copies as gifts or service awards in local activities. A printed 8 1/2-by-11-inch version of the Code is also available free of charge.

For a complimentary printed copy of the IEEE Code of Ethics, CIRCLE #71 on the Reader Service Card.

ELECTROTECHNOLOGY IN THE 1991 U.S. R&D BUDGET

This 10-page report prepared for the IEEE-USA's Technology Policy Council provides an overview of the Bush administration's Federal Fiscal Year (FY) 1991 budget request for research and development. The report highlights proposed funding for electrical and electronics technology programs in the Department of Defense (DOD), the Department of Energy (DOE), the National Aeronautics and Space

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Administration (NASA), the National Science Foundation (NSF), and the National Institute of Standards and Technology (NIST) in the Department of Commerce.

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NEW POWER SEMINAR

Human Factors Engineering at Nuclear Power Generating Stations

Pittsburgh, Pa.—September 24-25, 1990

The IEEE is sponsoring a new seminar, "Human Factors Engineering at Nuclear Power Generating Stations." The purpose of this course is to use human factors engineering (HFE) to help avoid disasters such as Chernobyl and Three Mile Island. The course will provide information about HFE concepts and terms and will help concerned engineers determine when to bring in outside HFE experts. This course will show how HFE can help reduce operating expenses, maintenance costs, and plant trips.

Attendees will receive a free copy of the IEEE standard on which this seminar is based, IEEE Standard 1023-1988 (ANSI approved), along with a complete set of lecture notes. Continuing Education Units are awarded to all those who successfully complete any IEEE Standards course.

For more information on this seminar, call 1-800-678-IEEE from the continental United States or Canada—just ask for Seminars on Standards. Or CIRCLE #73 on the Reader Service Card.

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The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

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All classified advertising copy must be received by the 25th of month, two months preceding date of issue. No telephone orders accepted. For further information contact Wendy I. Goldstein, 212-705-7578.

IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such [redacted] the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic
Positions Open

Drexel University. The Department of Electrical and Computer Engineering expects to have openings for tenure-track and visiting faculty primarily in the areas of Software Engineering, Computer Hardware, Integrated Manufacturing, and Power Engineering. The ECE Department has strong research efforts in Computers (logic design, VLSI, computer vision), Systems (control, power, robotics, signal and image processing), and Electrophysics (microwaves, optoelectronics, superconductivity, thin films). Faculty are expected to be active in research, and in undergraduate and graduate teaching. The department graduated about 220 BS, 60 MS and 15 Ph.D. in 1989. Applicants must have a Ph.D. Send Curriculum Vitae, including references, to Dr. Bruce A. Eisenstein, Head, Department of Electrical and Computer Engineering, Drexel University, Philadelphia, PA 19104. Immigration status of non-US citizens should be stated. Drexel University is an equal opportunity/affirmative action employer, and welcomes applications from women and minorities.

Caltech Electrical Engineering—The Division of Engineering and Applied Science of the California Institute of Technology invites applications for [redacted] tenure-track position in electrical systems. Candidates with broad interests in signal processing, [redacted] applied to speech and image processing, control, communications, sonar, radar, astronomy, etc., or to VLSI implementations of signal processing algorithms, [redacted] encouraged to apply. The successful candidate will be expected to develop an active research program and to teach undergraduate and graduate courses. Preference will be given to applicants at the Assistant Professor level, but exceptional candidates at higher levels may also be considered. Interested persons should send complete resume, including [redacted] description of research interests and the names and mailing addresses of at least three references to: Professor Robert McEliece, MS 116-81, California Institute of Technology, Pasadena, CA 91125. Caltech is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encourage to apply.

University of Colorado/Boulder. The Department of Electrical and Computer Engineering is seeking a quality tenure-track faculty member to further enhance its research and educational activities. This position is available for the academic year 1990-1991. Successful candidates must have an outstanding academic record, significant achievement in original research as well as interest in undergraduate and graduate education. A Ph.D. degree in Electrical, Optical and Computer Engineering or other related fields is required; salary and rank will be commensurate with qualifications and experience. Preference will be given to candidates at the Assistant Professor level but candidates at all levels will be considered. Areas of specialization include, but are not necessarily limited to, Computer Engineering, Controls; Electromagnetic Theory with application of Millimeter Waves, High Temperatures Superconducting Devices, Communications, and Bioengineering. The University of Colorado at Boulder has [redacted] strong institutional commitment to the principle of diversity in all areas. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people, including women, members of ethnic minorities and disabled individuals. Applications for this position should be sent to: Prof. Frank S. Barnes, Dept. of Electrical and Computer Engineering, University of Colorado, Campus Box 425, Boulder, CO 80309-0425. Deadline for application is June 10, 1990.

University of California, Riverside. The newly formed College of Engineering at the University of California, Riverside expects to make a faculty tenure/tenure-track appointment in the [redacted] of Electrical Engineering on or after March 1, 1990. While the appointment level is open, preference will be given to exceptionally qualified individuals having an established record in research. Applicants in all areas of electrical engineering are welcome. Research within the fields of real-time control, intelligent knowledge-based control, image processing, sensor analysis, computer modeling and simulation, non-linear system dynamics, integrated sensors, and computer architectures [redacted] of particular interest. The individual appointed will be expected to play [redacted] strong role in the development both of Electrical Engineering and the College of Engineering. Please submit a resume and names of at least three individuals willing to write letters of references to Chair, Search Committee, Electrical Engineering, College of Engineering, Riverside, California 92521. The University of California, Riverside is an equal opportunity, affirmative action employer.

Research Assistant—Ph.D. student (M.S. by 9-90) for project involving tunable monolithic analog IC, DSP, and optimization theory. Send resume, unofficial GRE scores and transcripts, names and addresses of three references, to RASP Facilitator, 318 WERC, Dept Elec Eng, Texas A&M U., College Station, TX 77843-3128.

Faculty Positions-University of Wisconsin-Madison. The Department of Electrical and Computer Engineering invites applications for tenure and tenure-track faculty positions. A Ph.D. degree is required, and successful candidates are expected to participate in both teaching and research activities. Applicants in all areas [redacted] invited to apply; of special interest are solid state and microelectronics including SiIC design and sensor research, III-V and II-VI electronic and optoelectronic devices and materials; computer engineering, with interests in computer architecture, computer networks, VLSI and computer-aided design, microprocessor and minicomputer applications, realtime control and instrumentation applications, engineering applications of artificial intelligence, and applications of supercomputers; electromagnetic fields and waves, including antennas and propagation, microwave and millimeter wave devices and applications, and high-power sources and associated transmission systems; electronics, including circuit simulation; photonics, including optical semiconductor devices, fiber and integrated optics, optical communication and processing; and plasma-aided manufacturing, including etching, deposition, spray, synthesis, polymerization, ion implantation, diagnostics, and modeling. Other areas currently active in the Department are: automatic control systems, biomedical engineering, communications and information theory, power systems, power electronics and drives, and plasmas and controlled fusion. Please send resume and names of three references to J. Leon Shohet, Chairman, Department of Electrical and Computer Engineering, University of Wisconsin-Madison, 1415 Johnson Drive, Madison, Wisconsin 53706-1691 [redacted] equal opportunity/affirmative action employer.

Trinity College—The Department of Engineering and Computer Science announces a tenure-track position, pending approval, in the field of Mechanical Engineering. It, therefore, invites applications from outstanding candidates for a position at the Assistant or Associate Professor-level commencing September, 1990, in the areas of Thermodynamics/Heat Transfer or Robotics/Controls. Experimental background highly desirable. The position involves graduate and undergraduate instruction and research, and a doctoral degree is [redacted] prerequisite. We are interested in receiving applications from women and minorities. Trinity College is an equal opportunity/affirmative action employer. Please send resume to Professor Joseph D. Bronzino, Chairman, ECS Department, Trinity College, Hartford, CT 06106. Consideration of applications will begin immediately and the search will remain open until the position is filled.

The University of Alabama in Huntsville The Department of Electrical and Computer Engineering invites applicants for tenure track positions at all faculty ranks. The Department had 630 undergraduate majors and 220 active graduate students. Position qualifications include U.S. citizenship or permanent resident status, Ph.D. in Engineering, ability to teach at all levels, supervise M.S. and Ph.D. candidates, and pursue funded research in areas such as communications, optical engineering, computer engineering, or modern electronics. Huntsville, a high-technology city, offers congenial living, a unique cultural environment, and many opportunities for Summer employment. Positions will remain open until they are filled. Send resume with names and telephone numbers of three references to: Chair, ECE Department, UAH, Huntsville, AL 35899. Telephone: (205) 895-6316. UAH is [redacted] Affirmative Action/Equal Opportunity Employer.

Endowed Professorship: The Department of Electrical Engineering at The Citadel invites applications and nominations for the endowed William States Lee Professorship in Electrical Engineering. Applicants should have a distinguished record as an engineering educator with [redacted] strong commitment to undergraduate engineering education. Qualifications include the Ph.D. degree in electrical engineering, industrial experience, an outstanding record of scholarly and professional achievement, and U.S. citizenship. Appointment will be at the senior Associate or Full Professor level. The recipient of the professorship will be expected to take an active roll in undergraduate teaching and the continuing development of the undergraduate curriculum with emphasis in the areas of engineering design, engineering laboratory courses and innovative teaching methods. The Citadel, located in beautiful historical Charleston, South Carolina, is [redacted] great place to work and Charleston is [redacted] wonderful place to live. Send a letter of application, resume, and the names of three references to: Dr. Harold W. Askins, Jr., Professor and Head, Department of Electrical Engineering, The Citadel, Charleston, SC 29409. Consideration of applications will begin on May

1, 1990, and continue until the position is filled. The Citadel is an equal opportunity/affirmative action employer

Chairman, Interdepartmental Graduate Program in Biomedical Engineering. Washington University School of Engineering and Applied Science. The Washington University School of Engineering and Applied Science is seeking a faculty member for the position of Chairman, Interdepartmental Graduate Program in Biomedical Engineering. The program faculty is comprised of faculty members from cooperating departments in the School of Engineering and the School of Medicine. The Program offers Master's and Doctor's degrees in Biomedical Engineering. The School of Engineering is seeking a program chairman who has an established research position in the biomedical engineering sciences, who has the abilities and qualities needed to provide academic leadership for the Program, and who would be qualified for a tenured position in one of the sponsoring engineering departments: chemical engineering, computer science, electrical engineering, mechanical engineering, and systems science and mathematics. Letters of inquiry should be directed to: Dean James M. McKelvey, School of Engineering and Applied Science, Washington University, One Brookings Drive, St. Louis, Missouri 63130. Washington University is an Affirmative Action, Equal Opportunity Employer.

The School of Engineering Science located at Simon Fraser University is seeking outstanding faculty candidates in control, robotics, and automation. Areas of interest include CAD/CAM/CIM, man-machine interfaces, vision, sensor systems, intelligent robotics, physical systems, modelling and design, dynamics and control. Prior industrial experience and an interest in electromechanical design would also be an asset. A strong research record is essential. The successful applicants will join a small research group working on topics related to automation engineering, and will also teach two courses per annum in his or her area of expertise, supervise graduate students, and participate in industrial interactions. Rank and salary will be competitive. Engineering Science provides an exciting educational environment demanding high academic standards of its students. Local industry offers many opportunities for faculty research and strong industrial links are characteristic of the program. New faculty members are encouraged to develop their own joint ventures. This academic environment is balanced by the natural and cultural ambience of one of the most attractive cities in North America. Moreover, the university itself enjoys a spectacular mountaintop setting, a short drive from downtown Vancouver. Preference will be given to candidates who are eligible for employment in Canada at the time of application. Applications from candidates not presently eligible for employment in Canada are welcomed but consideration of such candidates must be deferred until a Canadian search is complete. Positions are subject to budgetary authorization. To apply, send a curriculum vitae and the names of three references to Dr. Donald A. George, Director, School of Engineering Science, Simon Fraser University, Burnaby B.C. V5A 1S6, Canada.

Stevens Institute of Technology Department of Electrical Engineering is seeking tenure track faculty at all levels. The department is particularly interested in applied telecommunication areas, including performance analysis, congestion control, traffic modeling and measurements, mobile communications, and network and information services engineering. The department also seeks applicants in the areas of signal and image processing, and optoelectronics. Please send a resume and list of references to Prof. Paul M Chirlian, Department of Electrical Engineeirng and Computer Science, Stevens Institute of Technology, Castle Point on the Hudson, Hoboken, N.J. 07030. Stevens is an equal opportunity employer.

Carnegie Mellon University Position Available. Program Coordinator, Information Networking Institute. Carnegie Mellon University invites applications and nominations for the position of Program Coordinator, Information Networking Institute. The Institute, an interdisciplinary organization concerned with the use of computer and telecommunications technologies in business applications, grants and M.S. degree and conducts research in information networking. It also operates a continuing education, nondegree program in information networking. The Program Coordinator is responsible for the operation of this program. Applicants must have strong administrative skills and excellent teaching skills. Applicants should also have and M.S. degree in engineering, computer science, or business and significant experience relevant to information networking. Salary commensurate with experience relevant to information networking. Salary commensurate with experience. Applicants should include a current resume and the names, addresses, and telephone numbers of at least three references. Send applications and nominations to Dr. Alex Hills, Director, Information Networking Institute, Carnegie Mellon University, Pittsburgh, PA 15213. Carnegie Mellon University is an equal opportunity employer and actively encourages applications from ethnic minorities and women.

King Saud University, will have faculty positions in Electrical Engineering Department by September 1990. Candidates must have Ph.D., 5 years experience and strong interest in teaching, research and supervising M.Sc. Ph.D. Theses in the following areas: Digital Signal Processing, Antenna and Electromagnetic Theory, Electronics (Solid-State, VLSI, Semiconductor), Energy Conversion, Fiber Optics Communications and Computers & Control. The appointments will be made at the ranks appropriate with qualifications and experience. Send a complete resume, including a statement of teaching and research interest and a list of three (3) references to: Dean, College of Engineering, King Saud University, P.O. Box 800, Riyadh 11421, Saudi Arabia.

Dartmouth College, Thayer School of Engineering—Invites applications for non-tenure-track position, responsible for development of 3-D graphical software for computational electricity and magnetism, including finite element and boundary element mesh generation and graphical editing: postprocessing of vector and scalar solutions; and automatic generation of mesh contraints for CT and other anatomical data. Teach of engineering classes and supervision of graduate students required. Qualifications: Ph.D. in Electrical Engineering, knowledge of finite elements and the method of moments, ability for original programming in FORTRAN and also C, and demonstrated ability with 3-D graphics programming in a UNIX environment. Previous teaching experience required. Please send resumes and list of 3 references to: Daniel R. Lynch, Thayer School of Engineering, Dartmouth College, Hanover, NH 03755. Dartmouth College is an equal opportunity/Affirmative Action employer & encourages applications from women & members of minority groups.

Michigan State University, The Department of Electrical Engineering, invites applications for tenure track positions at the rank of Assistant or Associate Professor in the areas of computer engineering, solid state, systems & control, electromagnetics, electro-optics, signal processing and communications. The department offers B.S., M.S., and Ph.D. degrees in Electrical Engineering, and a B.S. degree in Computer Engineering. Michigan State University has an enrollment in excess of forty-thousand students. The Electrical Engineering Department has 26 faculty and a total student enrollment of 900, of which 150 are graduate students. Research expenditures for the department exceed 2-million dollars annually. The college is growing and has recently added a forty-thousand square foot engineering research complex and an eighty-thousand square foot addition to the engineering building. The college has modern computing and networking facilities, while the university provides a state-of-the-art mini-supercomputer facility. All faculty are expected to have a strong commitment to teaching at all degree levels and to demonstrate the ability to attract significant research support. A Ph.D. degree is required. Applications will be accepted until the positions are filled. Please send full resume, the names, addresses and phone numbers of three references and a statement of thesis status (if appropriate) to Dr. Jes Asmussen, Chairperson, Department of Electrical Engineering, 173 Engineering Building, East Lansing, MI 48824-1226. Michigan State University is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and members of minority groups.

The Electrical Engineering-Electrophysics Department at the University of Southern California invites applications for tenure-track faculty positions in Quantum Electronics, Photonics, Lasers and Optics, Optoelectronics, VLSI Circuits and Microsystems, Power System Devices, High Power Electronics. Resume and names of 3 references should be sent to, Prof. H.H. Kuehl, Chair, EE-EP, PHE 604, University of Southern California, Los Angeles, CA 90089-0271.

Faculty Position, Electrical Engineering: The Electrical Engineering Department of Parks College of Saint Louis University is seeking applicants at the Assistant Professor level for a tenure track position available September 1990. Responsibilities include undergraduate instruction, curriculum development, research and advising. The teaching areas include microelectronics, computer engineering, controls, communications, and signal processing. Ph.D. is preferred but an M.S. with appropriate experience will be seriously considered. Parks College, with an undergraduate enrollment of over 1000, is one of three campuses of Saint Louis University. Send resume with citizenship/visa status to: Dr. William Schallert, Chairman, Electrical Engineering Dept., Parks College of Saint Louis University, Cahokia, IL 62206 EOE M/F/H/V.

Washington State University College of Engineering and Architecture announces the availability of the Boeing Chair in Computer Engineering. The Department of Electrical and Computer Engineering at Washington State University invites nominations and applications for the Boeing Endowed Chair in Computer Engineering. Washington State University seeks an individual who has made significant contributions to the field of Computer Engineering to fill the chair endowed by the Boeing Company. The preferred candidate would be one whose primary interests are in computer systems design (e.g., networking, neural networks, high integrity systems, real time systems, computer architecture, CAD). Nominations of candidates from both industry and academia are welcome. A significant record of research funding and publications is expected. The Department actively participates in a number of research projects that are funded by the Washington Technology Center (WTC). The WTC was established by the State of Washington in 1983 to help promote research programs in the State's research universities that will be of benefit to the industrial sector in the State of Washington. The biennial budget for the Center currently exceeds $20 million. The individual chosen, will be expected to play a leading role in the WTC Computer Systems and Software Technology program which currently has a budget of over $2.7 million for the biennium. Recently, the Department has established an NSF Industry/University Cooperative Research Center for Design ofAnalog-Digital Integrated Circuits. The Center is currently sponsored by the NSF, WTC and 12 industrial companies. Depending on the area of specialty it is hoped that the Boeing Chair in Computer Engineering will actively interface with the Center personnel and its research programs. Candidates for this position must be capable of providing leadership for the continued expansion of the Computer Engineering program within the Department. As a tenured and distinguished Professor, the individual filling the position will be expected to teach, conduct funded research, and direct Ph.D. and MS student research programs. An earned doctorate in engineering, or a related discipline is required. The Department of Electrical and Computer Engineering has a full breadth undergraduate and graduate programs, offering the BS, MS, and Ph.D. degrees. Major research and academic programs exist in computer engineering, systems and controls, electronics and solid state power, and electromagnetics. The Department recently moved into a new building with expanded research and academic facilities. There are 240 certified (junior and senior) undergraduate majors and 90 graduate (MS and Ph.D.) students in residence on the Pullman campus. Additionally, the department has resident undergraduate and graduate pro-

grams with 80 students in Richland, Washington. Collaborative research exists between the computer engineering faculty and mechanical engineering faculty in the area of manufacturing ad robotics. Research and collaborative ties exist also with faculty at the University of Washington and the University of Idaho. Close working relationships exist between the university and the electronics industry of the Northwest. Letter of application, vita, and the names, and addresses of at least three references should be addressed to: Yacov Shamash Professor and Chair, Department of Electrical and Computer Engineering, Washington State University, Pullman, WA 99164-2752. WSU is an Equal Opportunity/Affirmative Action educator and employer. Protected group members are encouraged to apply.

Department of Electrical and Computer Engineering Washington State University, Pullman, Washington. The electronics program has traditionally been an important one in the College of Engineering at Washington State University, enjoying the support and respect of many leading industries. Recently a group of five such industries—Tektronix, Eldec, John Fluke Co., Data I/O, and Hewlett-Packard—have cooperated with the State of Washington to create an endowment for ■ "Distinguished Professorship in Analog Electronics." We are seeking applications and nominations for the position. The ECE Department offers programs leading to the BS, MS and Ph.D. degrees with areas of strength in Analog and Digital Electronics, VLSI, Computer Engineering, and other areas. We currently award approximately 100 BS degrees per year, and have approximately 90 fulltime graduate students enrolled. The Department has recently been strengthened with three endowed professorships, of which this is one. A second one, the Boeing Endowed Chair in Computer Engineering will also enhance the electronics program. Recently, the Department has established ■ NSF and twelve industrial companies. It is expected that the Distinguished Professor in Analog Electronics will actively interface with the Center Personnel and its research programs. Washington State University is a Land Grant University located in the beautiful rural area of eastern Washington State offering outstanding quality of life. The person filling this position must have: 1) An appropriate doctoral degree. 2) Evidence of successful outstanding research in analog electronics, with capability to assume a role of leadership. 3) Evidence of outstanding success as ■ teacher of undergraduate and graduate courses. 4) Proven ability to work cooperatively with academia, the electronics industry, and government agencies. Letters of nomination and/ or applications should be sent to: Dr. Yacov Shamash, Chairman, Electrical and Computer Engineering Department, Washington State University, Pullman, WA 99164-2752. Screening of applicants will begin March 15, 1990. WSU is an equal Opportunity/Affirmative Action employer and educator. Protected group members are encouraged to apply.

Engineering Research Associate. Major research and educational institution requires ■ research associate to develop and implement new physical models and numerical techniques in semiconductor device analysis, including one and two dimensional analysis programs such as SEDAN. S/he will also be responsible for interaction with industrial sponsors of the institutions's integrated system research facility. The position requires a knowledge of the field of device physics, modeling of bipolar devices (especially devices with heterostructures) and numerical techniques. Ph.D. in Electrical Engineering and three years of experience required. Salary $48,000 per year. Place of Employment and interviews: Stanford, CA. Send this ad and a resume to Job #AR 13329, P.O. Box 9560, Sacramento, CA 95823-0560 not later than May 26.

Electronics Technology—The University of North Texas invites applicants for a tenure track position in a new Electronics Technology program. ABET accreditation is being sought for electronics and manufacturing technology. Teaching assignment in circuit analysis, amplifiers, computer assisted circuit design, microcomputers, controls, and communications. BS degree in electrical engineering, electronics engineering technology, or associated area, and ■ masters degree. Doctorate required for continuation on tenure track. Industrial experience, P.E. registration, and prior teaching experience preferred. Salary and rank commensurate with qualifications. Send letter of application, transcripts, resume, references and 3 current letters of recommendation to Dr. John V. Richards, Chair, Department of Industrial Technology, P.O. Box 13198, University of North Texas, Denton, Texas 76203, phone 817/565-2022. Applications will be received until position is filled. Appointment effective September 1, 1990. The University of North Texas is an emerging national research institution in the Dallas-Fort Worth metropolitan area with over 26,000 students (one-third graduate students). The University of North Texas is an Equal Opportunity Affirmative Action Employer.

The Department of Ocean Engineering wishes to announce the availability of graduate research assistantships in the area of autonomous under-water vehicles. Students interested in pursuing graduate studies in sonar and video sensors, 3-D imaging, perception, map building, data representation and control architecture in a multi disciplinary environment should contact Dr. Stanley E. Dunn, Chairman, Department of Ocean Engineering, Florida Atlantic University, Boca Raton, FL 33431.

The Department of Electrical Engineering, Indian Institute of Technology, Kanpur, India invites applications from outstanding Indian Nationals for several faculty positions at Professor and Assistant Professor level. All areas of Electrical Engineering are open. A doctoral degree is a prerequisite. Candidates should have ■ strong commitment to teaching at undergraduate and graduate levels. Sponsored Research in the Department, being done under the Advanced Centre for Electronic Systems (ACES), is funded by several agencies and is at present above Rs.4.5. Crores. Candidates are expected to participate in group sponsored research. The areas of activities in the department include computer networking, digital communication, radar, telematics, digital systems, fibre optics, signal and image processing, electromagnetics, microwave systems, VLSI systems, microelectronics, biomedical electronics, solid state devices, modern control theory, power systems, HVDC systems, power and industrial drives, high voltage engineering, microprocessor applications, CAD, circuit and system theory, The Institute provides housing at reasonable rates. Its 400 hectare nicely landscaped campus has schooling facilities for the children ■ 24-hour-manned health centre and commercial facilities. Interested candidates are encouraged to send their resume and a list of three references with address to Professor Vishwanath Sinha, Head, Electrical Engineering Department, I.I.T. Kanpur, Kanpur-208016, India.

Professor: Electrical Engineering, Automatic Control Engineering Section. The Department of Electrical engineering of the Ecole Polytechnique de Montreal is seeking ■ professor of electrical engineering. Duties: The successful candidate will be called on to teach at all levels, participate in departmental research projects and eventually develop his or her own specific area of research. Requirements: Candidates should have a doctorate (Ph.D.) in electrical engineering, with specialization in automatic control engineering or ■ related field. They should have practical and theoretical experience in control systems encountered in the fields of robotics, aeronautics and aerospace sciences, and should be members of or qualify for membership in the Ordre des Ingenieurs du Quebec. Experience in industry would be a considerable asset. The working language at the Ecole Polytechnique is French. Salary and benefits: Salary and social benefits are in accordance with the policies in force at the Ecole Polytechnique. Start: September 1, 1990 at the latest. Applications must be sent, along with curriculum vitae and references, before May 15, 1990 to: Director, Department of Electrical Engineering, Ecole Polytechnique, P.O. Box 6079, Station A, Montreal, Quebec, H3C 3A7. NB: In accordance with immigration laws, this announcement is addressed to Canadian residents and permanent residents.

Hong Kong Polytechnic invites applications for the following posts: Department of Electrical Engineering—Principal Lecturer/ Senior Lecturer/Lecturer in one of the following areas: Automatic Control, Microprocessor Applications, Fields & Circuits, Power Electronics & Drives, High Voltage, and Power Systems. Department of Electronic Engineering—Principal Lecturer/ Senior Lecturer/Lecturer in one of the following areas: Computer System Software, Information Engineering, VLSI Design, and Electronics Manufacturing. Candidates should have a good honours degree or equivalent professional qualification and preferably a higher degree. For appointment at Principal Lecturer/Senior Lecturer level, candidates should have substantial professional/teaching/research/curriculum development experience. For appointment at Lecturer level, candidates should have some relevant post-qualification experience. Salaries—Principal Lecturer (HK$359,340 p.a.—$446,040 p.a.) Senior Lecturer (HK$303,180 p.a.—$392,880 p.a.) Lecturer (HK$166,440 p.a.—$289,800 p.a.) (Note: US$ = HK$7.797 ■ of 14 February 1990). Terms of Service: Initial appointment will be on a fixed term of contract of two years at the end of which ■ gratuity equal to 25% of basic salary earned over the whole contract period will be payable. Continuation thereafter is subject mutual agreement. Other benefits include leave, medical & dental schemes, and where appropriate, subsidized accommodation, passages and children's education allowance. Applications including curriculum vitae and names of three referees should be sent to the General Secretary, Hong Kong Polytechnic, Hung Kum, Kowloon, Hong Kong before May 28, 1990. Further information available from the same office (Fax: (852) 7643374).

Research Electronics Engineer. The high energy physics group at The University of Alabama invites applications for a new position as research electronics engineer. Present research activities include the design and evaluation of fast, ultra-sensitive charge preamplifiers in monolithic BiFET technology and fast digital buffers for generic detector R&D for the Superconducting Super Collider. Facilities within the group include an Apollo DN10000 mini-supercomputer and DN 3500 with 1 Gbyte hard disk, the MENTOR Graphics design software package, an HP 9000 workstation system complete with a 1 GHz digital waveform recorder, logic state analyzers, support electronics, and access to the Alabama Supercomputer Network. The ideal candidate should have extensive experience in analogue circuit design and familiarity with VME and fast digital VLSI design. An attractive competitive salary will be commensurate with experience. Please address vitae and three letters of reference to Professor Daryl DiBitonto, Department of Physics and Astronomy, The University of Alabama, Tuscaloosa, AL 35487-0324. The University of Alabama is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minority candidates.

Auburn University Research Associate. A position for a Research Associate is open in the Alabama Microelectronics Science and Technology Center of the Electrical Engineering Department at Auburn University. The successful candidate must have experience in ECR microwave plasma CVD and characterization of diamond thin films, ■ Ph.D. in EE, Materials Science, Physics or related discipline. Starting salary is $24,000/year. Please apply before July 1, 1990 by writing to Dr. Y. Tzeng, Department of Electrical Engineering, Auburn University, AL 36849-5201. Minorities and women are encouraged to apply. Auburn University is an equal opportunity and affirmative action employer.

The George Washington University, Marketing of Technology, Tenure-Track Faculty Position. A tenure-track faculty position is available in the graduate program of the Department of Engineering Administration, School of Engineering and Applied Science, starting Fall Semester 1990. The position requires: Ability to develop and teach courses pertinent to: marketing of technology, and/ or technology assessment, and/or technology transfer. Ability to generate and conduct sponsored research supported by funds from sources outside the University. Ability to academically advise degree candidates in fields of Engineering Administration at the masters, professional, and doctoral level. The George Washington University is located in the center of Washington, D.C. This metropolitan area sustains the second largest concentration of research and development activity in the United States, creating a continuing demand for rigorously trained engineers and many research opportunities. The Department of Engineering Administration conducts a major off-campus degree program at locations in the Washington metropolitan area and the person chosen for this position will participate in that program. The successful candi-

date will have an earned doctorate in an engineering or applied science discipline and will have been professionally associated for at least five years with some aspect of technology management. Salary and entry level academic rank will depend on qualifications. Applications will be reviewed beginning May 15, 1990, and will be accepted until the position is filled. Send vita and three references to: Professor Homer B. Sewell, Chairman, Department of Engineering Administration, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052. Affirmative Action/Equal Opportunity Employer.

Electrical and Computer Engineering. The Department of Electrical and Computer Engineering at West Virginia University anticipates open faculty positions in the areas of computer engineering, power systems, and communications and signal processing. Salary and rank will be commensurate with qualifications. Positions will be tenure track. Applicants must have the Ph.D., potential for high quality teaching, and will be expected to initiate research and participate in departmental research programs. A curriculum vitae and cover letter identifying an above [redacted] of specializations should be sent to: Chairman, Department of Electrical and Computer Engineering, West Virginia University, P.O. Box 6101, Morgantown, WV 26506-6101. Applications will be received and considered immediately and searches will continue until all available positions are filled. West Virginia University is [redacted] affirmative action/equal opportunity employer m/f.

Douglas Strain Professorship. The Oregon Graduate Institute of Science and Technology (OGI) is seeking to appoint the Douglas Strain Professor of Applied Physics and Electrical Engineering. The Strain Professor will play a major leadership role in strengthening the electrical engineering program of the department, including recruiting and mentoring junior faculty, while maintaining a strong, funded research program. The successful candidate will be an electrical engineer who has built a distinguished career in some aspect of signal processing, communications or a related field, as evidenced by the quality and quantity of publications and success in generating research funding. The level of achievement will be such as to qualify the individual for appointment at the full professor level. OGI is [redacted] small but rapidly growing private graduate-only institution, with a strong commitment to research and quality education. Reply to: Prof. Paul R. Davis, Head, Department of Applied Physics and Electrical Engineering, Oregon Graduate Institute of Science and Technology, 19600 N.W. Von Neumann Dr., Beaverton, OR 97006-1999. Tel: (503) 690-1138. FAX: (503) 690-1029. Applications received by June 15, 1990 will be given full consideration. EEO/AA.

Electrical Engineering Department, Gannon University has anticipated openings for one and possibly two tenure-track positions for Fall Semester, 1990. There is also a visiting professorship position available immediately. The successful candidate(s) will have responsibilities for teaching undergraduate and graduate students, course and laboratory development and supervising industrially sponsored projects. There is substantial opportunity to participate in ongoing research. The candidates must hold a Ph.D. and have [redacted] strong background in one or more of the following areas: embedded controllers, digital electronics, digital IC design, software engineering, electric machinery, or power electronics. Send vitae to Dr. S. Hazen, Chairperson, Electrical Engineering, Gannon University, Erie, PA 16541. Gannon University is an equal opportunity, affirmative action employer.

Assistant/Associate Professor Electrical Engineering. Pratt Institute invites applications for [redacted] full-time faculty position, available Sept. 1 1990. Primary responsibilities will be to develop and teach undergraduate and graduate courses and conduct research in telecommunications and computer engineering. We are making a significant investment in advanced laboratories to serve new curricula in these disciplines. Candidates must possess an earned Doctorate or equivalent industry experience. Teaching and practical experience in computer engineering, telecommunications or signal processing desirable. Salary and rank commensurate with qualifications. Review of resumes to begin immediately and accepted until position is filled. Please submit resume, including three references to: EE Faculty Search Committee, c/o Human Resources Department IES, 200 Willoughby Avenue, Brooklyn, New York 11205 AA/EOE.

Electrical Engineering Faculty Position— Hampton University is seeking an enthusiastic and assertive Assistant/Associate Professor for a tenure-track position in its Electrical Engineering program. Duties include teaching, the development of a funded research program, and a service to the University and the profession. Persons applying should have: Ph.D. in Electrical Engineering or equivalent, teaching experience and expertise in Digital Systems Design and Communication. The ability to interact effectively with minority students in small classes is crucial. The Department has just moved into a state-of-the-art modern facility for teaching and research. Applications with curriculum vitae including [redacted] statement of teaching and research interests, and the names of at least three references should be sent before May 15, 1990 to: Dr. Robert D. Bonner, Dean, School of Pure and Applied Sciences, Hampton University, Hampton, VA 23668. For further inquiry concerning this position, contact Dr. Adeyinka A. Adeyiga, Chairman, Department of Engineering at (804) 727-5288. Hampton University is an equal opportunity, affirmative action employer.

Faculty Positions in Computer Science and Information Systems. The School of Science and Engineering invites applications from individuals who have [redacted] strong leadership quality and interest in teaching graduate and undergraduate courses, in research, and in interaction with industry; to help in expanding and implementing its degreee programs in Computer Science and Computer Information Systems. The School, known for its close faculty-student interaction and intense laboratory experience seeks to implement competitive course and laboratory work in the areas of CIS, Networks, Graphics, and Compiler Design. A new VAX based computer network has just been completed. Ample opportunities are available for professional growth and interaction with an active and collegiate faculty supervising [redacted] variety of funded projects. Wilkes is a comprehensive university in close proximity to the industrial and cultural centers of Boston, New York, Philadelphia, and Washington DC. Faculty members are encouraged to establish strong ties with industry and national laboratories. Candidates for the postion(s) should have an earned Ph.D. or be in the final stages of the degree. A complete resume (including citizenship or visa status and three references) should be submitted to: Dr. Brian Redmond, Associate Dean, School of Science and Engineering, Wilkes University, Wilkes-Barre, PA 18766. Minorities and Women are encouraged to apply. AA/EOE.

Endowed Professorships School of Engineering and Applied Science, The George Washington University. The School of Engineering and Applied Science of The George Washington University is seeking to fill two newly endowed professorships. The L. Stanley Crane Professorship will be appointed in the Department of Electrical Engineering and Computer Science and the A. James Clark Professorship in the Department of Civil, Mechanical and Environmental Engineering. One professorship will be appointed in the 1990-91 academic year and the onther in the 1991-92 academic year. Each appointment will be coordinated with programmatic developments for a new campus that the University is opening in Northern Virginia in 1991. Initially, academic programs on that campus will focus primarily on graduate education and research. Individuals with a preeminent record of accomplishments are sought; an academic background is desirable. The successful candidate for each professorship will have an outstanding record of research and publications, a sustained record of performance within industrial and/or gonvernment spheres, and recognition in both domestic and international organizations. A review of resumes and supporting documentation will commence on April 16, 1990 and continue until the positions are filled. Submit credentials to: Professor Sam Rothman, Chair, Selection Committee for Endowed Professorships, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052. The George Washington University is [redacted] Equal Opportunity/Affirmative Action Employer.

Faculty Positions School of Engineering and Applied Science, The George Washington University. New and challenging opportunities for faculty appointments, both tenure-track and research, at the ranks of assistant, associate, full, and distinguished professor are available in the School of Engineering and Applied Science beginning Fall Semester 1990 and Spring Semester 1991 in various specialty areas. These positions may require faculty to participate in new programs in Northern Virginia and other off-campus locations in the Washington metropolitan area. The George Washington University is located in the center of Washington, D.C. This metropolitan area sustains the second largest concentration of research and development activity in the United States, creating a continuing demand for rigorously trained engineers and many research opportunities. The School of Engineering and Applied Science is organized into four academic departments: the Department of Civil, Mechanical and Environmental Engineering; the Department of Electrical Engineering and Computer Science; the Department of Engineering Administration; and the Department of Operations Research. Faculty will be expected to teach undergraduate and/or graduate courses, to interact with faculty colleagues in inter-disciplinary specialty areas, and to conduct and promote sponsored research in their specialty areas. Two senior faculty members selected will be assigned additional responsibilities to the above in performing the duties of [redacted] Research Director and Chief Scientist. Candidates with expertise in the following specialty areas are especially valued: aerospace, aerospace mission analysis, artificial intelligence, communications, composites, computational fluids and solids, computer-integrated manufacturing, computer science, expert systems, foundational structural engineering, human factors engineering, marketing of technology, mechanics of materials and structures, reliability, robotics, software engineering, structures, systems analysis and engineering, systems engineering and management (e.g., energy and environmental management, project and program management, biotechnology management, total quality management), and VLSI. Candidates in other engineering or applied science specialty areas are also encouraged to apply. Candidates should have an earned doctorate in engineering or a related discipline and research experience with [redacted] interest in both teaching and research. Good communications skills, both oral and written, are essential. Registration as a professional engineer is desirable. Salary and rank will be commensurate with qualifications and experience. Applications will be reviewed beginning April 16 and will be accepted until the positions are filled. Applicants should send their vitae including a list of publications with three references to: Office of the Dean, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052. The George Washington University is a Affirmative Action/Equal Opportunity Employer.

The Thayer School of Engineering at Dartmouth College invites applications for tenure-track appointments. Of special interest are candidates with experience in analog or digital VLSI circuits, but outstanding candidates in all areas of computer engineering are encouraged to apply. Interested persons should submit [redacted] resume and names of three references to Prof. Charles Hitchcock, Thayer School of Engineering, Dartmouth College, Hanover, New Hampshire 03755. Dartmouth is an equal opportunity, Affirmative Action employer and encourages applications from women and members of minority groups.

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Electronics Engineers—Washington, DC/Maryland/Virginia. Engineering placement Leaders since 1973. Specializing in Product Development (Hardware & Software), Communications, Artificial Intelligence, Military Electronics, Computer Engineering and VLSI/ASIC. Direct resume to: JDG Associates Ltd., 1700 Research Blvd., Rockville, MD 20850 - (301) 340-2210.

Electrical Engineers. 713-780-4640. Send Resume. CPS, 2640 Fountainview #340, Houston, TX 77057.

Editorial—Publishing—Leading technical book publisher needs manuscript editor/evaluator with computer, gov't contract, and/or electronics background. College degree required. Command of English language essential. Editing experience desirable. Excellent benefit package. E.O.E. Send resume to: Kathryn Holtz, Director of Human Resources, TAB BOOKS, A Division of McGraw-Hill, 13311 Monterey Avenue, Blue Ridge Summit, PA 17294-0105.

Senior Regional Marketing Manager for Latin America for manufacturer of electric generating sets. Duties: Assist distributors in Latin America by evaluating their sales, service, and parts operations performance ■■ well as assissing and resolving their problems, proposing new markets and marketing strategies, and ensuring they have adequate inventories. Ensure dealer and distributor familiarity with company products and replacement parts. Provide sales training to sales distributors in Latin America of new and existing products. Assist the Regional Director in developing and coordinating the synergies of the company relationship consistent with the long range strategic direction of the corporation. Position involves travel throughout South and Central America up to 70%. Salary: $44,000/ year. Fulltime. REQ: Bachelor of Science in Engineering; fluent in spoken and written English and Spanish; Five years experience in Sales of Electrical Products Equipment including 3 years experience in South and Central America, 2 years of general management experience in distributorships for profit, and ■ least 3 month training in electrical generating equipment. Send resume only to Job Service of Florida, 701, S.W. 27 Avenue, Room 15, Miami, FL 33135. Ref: Job Order #FL 0234799.

Advanced Control Systems Engineer—Primary duties are to develop, design, solve application problems, and implement process control systems for laboratories and production facilities in order to develop and manufacture products of worldwide competitive quality, performance and price. Engineer with a Master of Science degree in Electrical Engineering with an emphasis in advanced analog/digital control theory is required. Candidate must have five months industrial experience in control system modeling, simulation and integration. Must have five months industrial experience in control system modeling, simulation and integration. Must have experience or education in application of variable speed AC/DC drive control systems, programmable controllers, microprocessor based process measurement/ control systems, data acquisition/ handling systems, automation/robotics, real time artificial intelligent applications, and programming knowledge in Lisp/Prolog, Assembler, C, and Fortran. Must have education and experience in modeling dynamic systems requiring robust adaptive type and variable structure type control systems. Salary $35,880 per year. Send resume to: Dick Hewetson, #0-55, Minnesota Department of Jobs and Training, 390 N. Robert Street, Room 124, St. Paul, Minnesota 55101. An Equal Opportunity Employer.

Sr. Electrical Eng.—40/Wk. $52,000/Yr. Requirements Ph.D. E.E. w/1 yr. exp. in related communications antenna positions. Duties research, design, development and manufacture of new and advanced communications, navigational, DME, GPS and directional finding antennas. Required exp. formal education and experience in advanced science and engineering principles and programs, numerical analysis, microwave measurements, advanced antenna theory, phased array antennas, microstrip antennas and radar systems; requirements for direct experience in the measurements and computer modeling of antenna phase and phase center characteristics for UHF and GPS positioning systems to include LPA, YAGI, Corner Reflector, LOG spiral, monopole and quadrifilar helix antennas; experience with development of computer models for antenna performance simulation using method of moments and general circuit techniques; experience with the development of phase center position formulation and phase center effect on phase and time based positioning systems; experience with direct measurement and characterization of phase and phase center performance of Chu Associates GPS antennas to include the CA-3350 and the CA-3413 and/ or the CA-3423. Job site and interview-El Cajon, CA. Send ad and resume to: MLU 13363 P.O. Box 9560 Sacramento, CA 95823-0560 no later than June 15, 1990.

Electrical Engineer—Design electronic remote controlled monitoring devices for animal research purposes. Produce drawing of prop. devices using computer-aided design software. Test model devices to locate & resolve electronic/ programming deficiencies. Write controller programs in various computer languages. Install device & provide customer training & support. Estab. process to retrieve data from device through radio transmission. Supervise technicians who construct the devices and supervise prep. of service forms. Coursework & work exp. with design of radio transmission/remote control devices. Work exp. with computer aided system design and programming, and with C, Basic, Pascal, Fortran, M68000, UNIX, VAX, NOS, SUN 4.0, SUN 3 series and IBM computers. BSEE or Bachelor in Comp. Sci. req. 1 yr in job offered or 1 yr in R&D—system design/remote control devices $576.80/ wk. Job site & interviews: Billings, Montana. Send ad & resume to: Job Order No. 0421889, G.H. Lythgoe, Job Service of Montana, 1425 Broadwater, Billings, MT 59102, no later than May 31, 1990.

Systems Analyst. Responsible for the development of a computer-based expert demand forecasting system for polymers and petrochemicals; duties include development of forecasting methodologies, intermaterial substitution simulator, database structures, and graphic user interface, etc. Requires Ph.D. in Engineering-Economic Systems, Operations Research, or Systems Engineering. Also requires advanced knowledge of mathematical optimization theory and system theory; probability theory and statistics, decision analysis and competitive analysis; expert system or decision support system design; business applications of artificial intelligence; knowledge of Prolog, Fortran, Pascal and C; and knowledge of PC networks. Salary : $4,216.50/ month; 40 hours per week. Job and interview site: Menlo Park, CA. Send this ad with resume to Job # MLU# 13665, Box 9560, Sacramento, CA 95823-0560 not later than May 31, 1990.

Applications Engineer: Challenging position to develop advanced technology in power and distribution equipment, with focus on new insulation materials and computer analysis for "next generation" designs. Combined research and marketing interactions, leading to program management with worldwide opportunities. Develop and manage new laboratory test facilities for analysis of materials in liquid environments. Work within industry/ professional societies (IEEE, NEMA, etc.) to develop new standards. Requires degree in power engineering or EE with 5+ years experience in the power industry. Requires Northeast location and considerable travel. Background in computer design and/or applications programming desired. Applications engineering experience with materials inters in power transformers desirable. Please send resume to: R.L. Provost, DuPont Co., Chestnut Run OR-100, Wilmington, Deleware 19880-0701.

Assistant Director—Cardiovascular blood flow Surgical Laboratory. Establish blood flow surgical research laboratory for patients with total artificial heart and other circulatory assist devices such as ventricular assist devices and intra-aortic balloon pump; conduct hemodynamic evaluations of the patients with cardiac assist devices utilizing non-invasive methods such as ultrasound; conduct hemorheologic evaluations of the blood of patients with cardiac assist devices by viscometry; utilize ultrasound and pulsed Doppler techniques. Ph.D. in Bioengineering required together with 1 year and 6 months experience in the job offered or 1 year and 6 month experience as ■ Research Assistant. Must have published in a peer-reviewed journal in the area of blood flow dynamics in systemic circulation and arteries utilizing ultrasound real-time B-mode images and pulsed Doppler techniques. Experience with title of Research Specialist acceptable. 40 hrs, M/F, overtime as needed, 8am to 5pm, $40,000/yr. Send resumes to: Illinois Department of Employment Security, 401 South State Street—3 South, Chicago, Illinois 60605, Attn: Joan Sykstus, Reference #V-IL 1062-S. An employer paid ad.

Postdoctoral Position: DLR (German Aerospace Research Establishment), is seeking a senior scientist for establishing the research area "Processing of spatial information from stereoscopic and laser scan data. Sensor- and knowledge-based generation of 3D world models on high-performance stereo-graphic systems. Application to sensor-controlled, teleoperated and autonomous robots (e.g. grasping of free floating objects in space)". Applicants should have ■ Ph.D. degree and several years of qualification in the area of robotics, machine vision and artificial intelligence, Job site: Oberpfaffenhofen near Munich. Send resumes to: Dr. G. Hirzinger, Tel. 01149 8953 28401. DLR FF-DF, D-8031 Wessling, FRG.

Digital Engineer. The SETI Institute, under cooperative agreement with NASA, is developing an advanced observing system to search for signals from extraterrestrial civilizations. This system will include a 10 million channel spectrometer with real-time signal processing in dedicated computer systems. A position is available for ■■ Electrical Engineer with a graduate degree or 5 years experience. Work will include board level design, development integration, and testing of hardware implementations of signal detection algorithms. Experience with high data rate buses and large memory systems is important. The system will handle data at rates of 20 MB/second and have computation loads of about 1 GFlop. Computer facilities include UNIX workstations. Control software is written in C. Salary will be commensurate with experience. Applicants should submit a resume, salary history and the names and addresses of three references by June 15, 1990 to SETI Institute, 2035 Landings Drive, Mountain View, CA 94043, Attn: Signal Detection Position. This work will be conducted at the NASA Ames Research Center. EOE/AAE.

Government/Industry Positions Wanted

Ph.D. with experience in statistical communicat. theory, optical based signal processing systems, Research publications. Strengths include numerical analysis, comp. simulation. Seeks position. 227 Adams St. Newton, MA 02158 (617) 244-8307.

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Won't you be our neighbor?

To avert environmental destruction, the United States must avail itself of resources in nearby space, Representative George E. Brown Jr. (D-Calif.) told the IEEE-U.S. Activities Aerospace R&D Committee on March 21. This fundamental shift in the U.S. space policy would call for viewing the Earth, the moon, all the orbits within the Earth-moon system, and five points along the Earth's orbit as part of a "neighborhood" called Greater Earth. The United States must take advantage of the resources available in surrounding Greater Earth to conserve Earth's resources, he said.

This shift in policy would be part of the United States' role as a leader in space, Brown said; the United States must also be a competitor and a partner to remain a world leader. To compete with Japan and Europe, the Government must continue to fund key technologies, or other countries will. But the United States must also cooperate with others on such projects as the space station to distribute the cost and improve international relations, he said [THE INSTITUTE, May/June, p. 1].

Award recipients announced

The recipients of the IEEE's major medals, prize papers, service awards, and recognition awards have been announced by the Board of Directors. Most of the presentations will be made at the Oct. 6 Medals Presentation at the IEEE Sections Congress in Toronto [THE INSTITUTE, May/June, p. 2].

A calculator for the teacher

IEEE Spectrum has announced the seven winners of its Precollege Innovative Math/Science Education Competition, which sought unusual and effective educational programs. The winners and those who nominated them will be given Hewlett-Packard HP-28S calculators; two more candidates for awards are in review.

The contest was announced in the March 1989 Spectral Lines column in *Spectrum*, and information was mailed to educators, technology leaders, and editors of major science and technology publications. *Spectrum* screened the nominations and received evaluations from an advisory board of esteemed educators.

Some of the award-winning programs have been covered in the December, March, April, and May/June issues of THE INSTITUTE. The others will be described in future issues [THE INSTITUTE, May/June, p. 6].

Engineering in the USSR

As the Soviet Union has grown more democratic, guiding one of the country's major research institutes has become increasingly challenging, according to Yuri V. Gulyaev, director of the USSR Academy of Sciences' Institute of Radio Engineering and Electronics in Moscow. While the institute earned more funds last year than it had been automatically granted the year before, it required more work to compete for grants with other bodies, he told THE INSTITUTE.

Glasnost will allow Soviet scientists and engineers to establish contacts with colleagues in other countries and to pursue additional research interests, said Gulyaev, who is also president of the A.S. Popov Society, a Moscow-based technical society with which the IEEE recently reestablished ties. The Popov Society hosted a recent visit to the Soviet Union of an eight-member IEEE delegation on optoelectronics. A like number of Soviet engineers and scientists were to attend in April the International Conference on Communications in Atlanta, Ga. [THE INSTITUTE, May/June, p. 7].

East Europeans joining the IEEE

In the wake of the dramatic political changes in Eastern Europe, electrical engineers in the newly open countries are forming IEEE Sections. So far, the IEEE has been told of efforts in Romania, Czechoslovakia, and Hungary, with the Romanians particularly eager to make IEEE contacts because the flow of technical information into and out of the country was almost nil under the regime of Nikolai Ceaucesceu.

Finding the required 50 members for a Section and enough U.S. currency for member dues are the main difficulties East Europeans face in forming a Section. The Romanians' monetary problems have been solved by the United Nations Educational, Scientific, and Cultural Organization, which has promised to cover dues for 50 members [THE INSTITUTE, May/June, p. 7].

COMING IN SPECTRUM

Europe '92. By the end of 1992, the 12 members of the European Community (EC) plan to be a single market, within which their goods, services, capital, and workers will move freely. The lure: over 300 million potential customers. The hope: an assured position on the leading edge of technology and hence of economic growth.

Every area of electrotechnology—from computers to semiconductors—is being affected. Standards must be coordinated throughout all 12 countries. Multinational corporations are regrouping. Electrical engineers face a new environment, requiring greater adaptation and mobility. Professional associations will form closer liaisons with one another and their umbrella organization, Eurel.

The recent upheavals in Eastern Europe and the USSR also are having an impact. In a special issue, *IEEE Spectrum* will survey the status of consolidation efforts, the major corporate players, and the implications of these historic changes for the electronics industry and the world.

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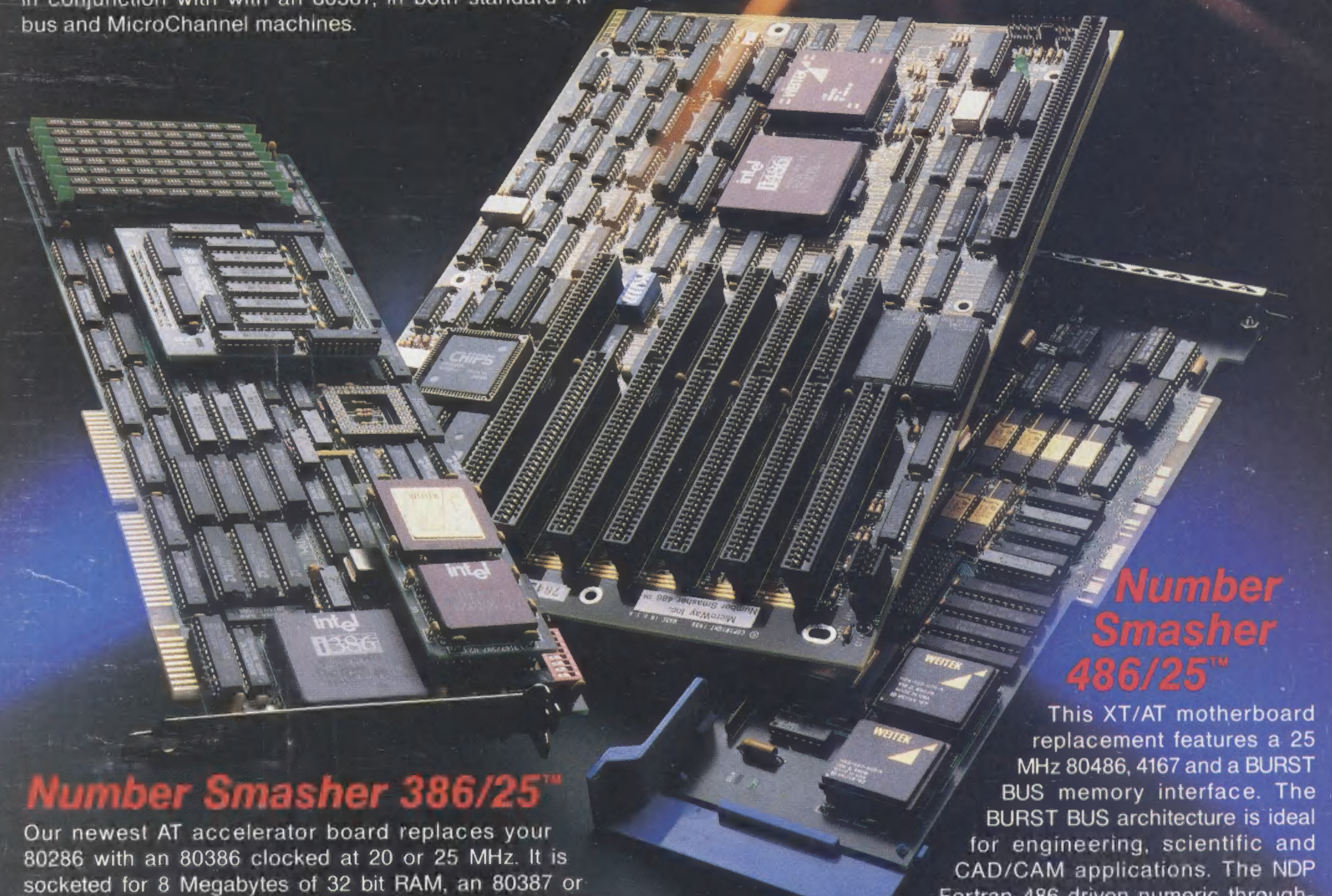

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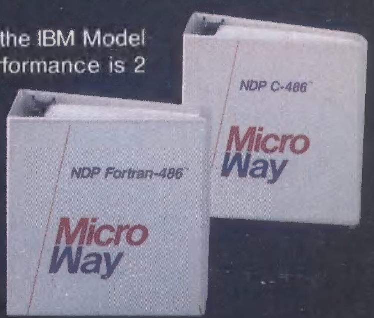

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